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Report of the

EXPERT CONSULTATION ON UTILIZATION AND CONSERVATION OF AQUATIC GENETIC RESOURCES

Grottaferrata, Italy, 9-13 November 1992

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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REPORT OF THE EXPERT CONSULTATION ON UTILIZATION AND CONSERVATION OF AQUATIC GENETIC RESOURCES

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1993

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The proceedings of the Consultation, including experience and background papers, will be published as a supplement to the current report.

Distribution:
FAO Fisheries Department
FAO Regional Fisheries Officers
Directors of Fisheries
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ABSTRACT

This report discusses the need and methodologies for the utilization and conservation of genetic resources of aquatic animals. More than a review of genetic principles and technologies, the report addresses the application of such principles and technologies in development and conservation projects and research.

Specific recommendations are made with regard to the genetic resources contained in natural populations, fisheries stocks, and aquaculture. Recommendations concerning regulatory, policy and legal aspects of aquatic genetic resources are also presented.

TABLE OF CONTENTS

FORWARD 1

INTRODUCTION 1
Objectives 2
Organization of the consultation 2

RECOMMENDATIONS 3
Preface to the Recommendations of the Expert Consultation 3
General 3
Natural populations 6
Introductions and transfers 7
Stocking and enhancement programmes 8
Fisheries and fishery related activities 9
Aquaculture 12
Policy and regulation 15

LITERATURE CITED 17
Annex A: Selected FAO activities in genetic resource utilization and conservation in Aquaculture and Fisheries 1970-1990 18
Annex B: Questionnaire on the utilization and conservation of aquatic biodiversity 19
Annex C: An indication of the application of genetics to the major cultured groups of finfish groups of finfish, molluscs and crustaceans 22
Annex D: Some operational definitions pertaining to genetic resources 23
Annex E: Abstracts 24
FAO Programme on Animal Genetic Resources 27
FAO Global System for the Conservation and Sustainable Use of Plant Genetic Resources 28
FAO Activities on Forest Genetic Resources 29
Legal Aspects of the Conservation and Utilization of Aquatic Gene Resources 30
Genetic Markers and Mixed Stock Fisheries 32
Effects of Fishing on Genetic Resources of Aquatic Organisms 33
Protection of Rare Aquatic Wild Animals in China 34
Genetic Conservation of Freshwater Fishes in China 36
Methods for Assessing Genetic and Biological Diversities 37
Ecological and Regulatory Uncertainties Associated with Transgenic Fish 39
Field Experience with Cryopreservation, a Practical Tool for Genetic Conservation in fishes 40
Biodiversity and Aquaculture in Southern Africa 41
Promoting On-Farm Genetic Conservation in Aquaculture 42
The Project on Genetic Improvement of Farmed Tilapias 43
Effects of Selection for Polygenic Traits on Genetic Diversity 46
Standardization of Infra-Specific Nomenclature in Aquaculture 47
Fisheries Research in FAO 49
Implications of UNCED on the Fisheries Department Work Programme 50
Annex F: List of documents 57
Annex G: Agenda 52
Annex H: List of participants 54

FORWARD

The Food and Agriculture Organization, as an autonomous agency within the United Nations, is a source of expertise and information for research and development in the agricultural, forestry and fishery sciences; it provides a forum for its member countries to identify and resolve common problems, to share research competence and data, and to agree on cooperative and coordinated action. The mandate of the Organization, as established in its Constitution and affirmed by its member countries, is i) to raise the levels of nutrition and standard of living of its constituents, ii) to improve the production and distribution of all food and agricultural products, and iii) to improve the condition of rural people. Member Governments expect FAO to exercise leadership as both an academic research institution and as an active development partner to meet the needs of the present and future world population. The utilization and conservation of genetic resources of aquatic organisms are seen as important means to help fulfil FAO's mandate.

In light of recent international conventions and action plans, particularly the Convention on Biodiversity and Agenda 21 from the United Nations Conference on Environment and Development (UNCED 1992a,b), the time is right for a strong international effort aimed at optimizing the use and conservation of aquatic gene resources. Capture fisheries in 1991 harvested approximately 84,250,813 metric tonnes from marine, brackish, and freshwater environments. Aquaculture production for the same year was 12,675,087 metric tonnes (FAO 1992a), however, aquaculture is expected to play an increasingly important role in meeting the protein requirements of a growing human population. The wise use of genetic resources, biotechnology, intellectual property rights and patenting will play a vital role in the sustainable harvest and production from the aquatic sector, as well as in the protection of valuable natural populations in the aquatic environment.

Although the Fisheries Department has made significant progress promoting understanding and action among its member governments in utilization and conservation of genetic resources in the last decades, the aquatic sector lags behind other sectors concerned with terrestrial forms of agriculture and forestry in implementing these concepts. In order to provide FAO with advice on how fishery and aquaculture projects can achieve the optimum means to both utilize and conserve genetic resources, this Expert Consultation on Utilization and Conservation of Aquatic Genetic Resources was convened.

INTRODUCTION

The world we live in consists of a tremendous wealth of plant and animal resources. The various forms of these organisms have contributed to the betterment of humankind by providing material for agriculture, forestry, and fisheries, by providing natural and aesthetic refuges from our more industrialized, mechanized or stressful daily lives, and by providing spiritual experiences for a variety of human cultures. The term biological diversity has come to signify this organic variability at all levels of complexity, from molecular diversity, to organismal, population, community, and finally to ecosystem diversity. However, underlying this hierarchical structure is the basis for the processes of biological change, adaptation, and evolution, namely genetic diversity. Thus, to ensure the maintenance of biological diversity and its benefits to humankind, an understanding of the processes and organization of genetic diversity and genetic resources will be essential.

In the face of rapid and unprecedented loss of biological and genetic diversity, especially in tropical developing countries, FAO is emphasizing the importance of utilizing natural resources within a framework of sustainable development and conservation. The 25th Session of the FAO Conference stated that FAO should actively contribute to international agreements on biological and genetic diversity. The 98th Session of the FAO Council recommended that FAO should play an active role and give due priority to conservation and the rational use of biological/genetic diversity of interest to agriculture, forestry, and fisheries.

Although work of other departments within FAO has provided models and recommendations for the conservation and utilization of genetic resources, the aquatic sector, i.e. fisheries and aquaculture, provides special concerns, constraints, and considerations that must be addressed. One significant difference between fisheries and the other sectors is that the majority of the utilization of fishery resources is of wild or natural stocks. Even in intensive aquaculture systems, the fish cultured are usually very similar to those still found in the wild. With the exception of a few strains, not many fish species have been domesticated for food production.

Objectives

The primary objective of the Consultation was to provide the Fisheries Department with direction and priorities in the management of aquatic genetic resources so that such information can be utilized by member nations and the international community. In this respect, the Consultation sought to build on past experiences of the genetic programmes of FAO and elsewhere, and to integrate its recommendations within the framework of the United Nations Conference on Environment and Development. FAO has made significant progress in the fields of aquatic genetic resource utilization and conservation and this Consultation sought to draw heavily on the activities listed in Annex A.

Over a decade ago, the first Expert Consultation on genetic resources (FAO/UNEP 1981) was convened by the Fisheries Department, FAO in conjunction with the United Nations Environmental Programme (UNEP). This significant contribution to the field focused on technical matters and genetic theory. In the ten years following the first consultation advances in technology and theory of genetics have been made. However, the application of these principles and technologies to practical problems of fish farming, fishery management and conservation have been slow to materialize. Therefore, an additional concern of the present Consultation was to try to understand the reasons for the failure to utilize genetic principles and determine how to correct the shortcoming.

Organization of the consultation

Given the fact that genetic principles have been applied in only a few practical situations in the aquatic environment, the Consultation was designed to address basic and general issues on the need and suitability of utilizing and conserving aquatic genetic resources in fulfilling FAO's mandate to improve conditions in developing and rural areas. The Consultation was indeed fortunate that Dr. Fred Utter agreed to serve as its Chairman to maintain order, focus and facilitate discussions.

To acquaint the participants with the priorities and scope of the Fisheries Department's activities, the results of an informal survey of FAO field projects (Annex B) were presented to the Consultation. The responses to the questionnaire demonstrated that some genetic principles, new ideas and new technology are not reaching the end users, the farmers and fisheries concerned with sustainable development.

Following presentations of information and background papers (Annex E) the participants were organized into four working groups: 1) policy and regulations, chaired by Dr. Graham Gall, 2) natural populations, chaired by Dr. Valerio Sbordoni, 3) aquaculture, chaired by Dr. Gideon Hulata, and 4) fishing and fishery-related activities, chaired by Dr. David Coates. The groups were asked to provide brief overviews of the subject of their working group, to identify central issues and problems and to address the following series of broad questions:

1. Is the application of genetic principles important/appropriate for perpetuating productivity in developing countries or rural areas?

2. Should the genetic resources of aquatic species be considered differently from genetic resources of terrestrial plants and animals?

3. Does adequate information exist to utilize and conserve aquatic genetic resources?

4. Do adequate technical tools exist to address the problem of effective utilization and conservation of aquatic genetic resources?

5. Is the nomenclature standardized and adequate?

6. Why has information on genetic resources failed to be utilized or not reached users?

RECOMMENDATIONS

Preface to the Recommendations of the Expert Consultation

In light of the often blurred boundaries between the subjects of aquaculture, fisheries, and natural aquatic populations, it was not surprising that the working groups identified many similar problems and made similar recommendations with regards to genetic resource conservation and utilization. Therefore, the recommendations of the working groups have been re-organized into the following categories: general, natural populations, stocking and enhancement, introductions and transfers, fisheries and fishery activities, aquaculture, and policy and regulatory aspects. These sub-headings were chosen to facilitate use of these recommendations and to provide easy access to specific sections. Increasingly, the management of aquatic genetic resources will involve multi-disciplinary actions, the aquaculturists must be aware of the impacts of the farm on wild biota, as well as be aware of the natural genetic resources available to help increase the farm's production. Fisheries managers must be aware of the advantages and threats of stocking, introducing and transferring aquatic organisms to rehabilitate fisheries, and must take care not to disrupt natural aquatic communities and subsistence fisheries.

In light of the priorities with the Fisheries Department of FAO, the Consultation was directed to give primary consideration to the genetic resources of aquatic animals. Although aquatic plants were not discussed during the Consultation, the Consultation suggested that FAO should consider the need for a similar consultation on behalf of aquatic plant genetic resources and may additionally wish to include aquatic micro-organisms.

General

In accordance with the Convention on Biological Diversity (UNCED 1992b), Agenda 21 (UNCED 1992a) and the United Nations Law of the Sea (UNCLOS 1982), the Consultation recognized that aquatic animal genetic resources are an essential resource for humankind, that conservation of aquatic animal genetic resources is a common concern of humankind, that nations have sovereign rights over their aquatic animal genetic resources and that there are aquatic animal genetic resources shared by nations. The Consultation recommended that national governments and international organizations take responsibility for the application of sound conservation principles to manage genetic resources within their jurisdiction.

The Consultation stressed that the application of genetic principles will be necessary to insure sustainable food production and a good quality of life in developing countries and rural areas. However, the Consultation recommended that these principles should be applied within the broader contexts of ecology, limnology, marine biology, political priorities and socio-economics.

The Consultation recommended the development and enforcement of regulations for conserving genetic resources, the fostering and promotion of international conservation activities of shared genetic resources, the provision of funding for conservation activities, and the

coordination of public education activities in support of conservation programmes. Specifically, the Consultation recommended that organizations in support of aquatic genetic conservation attempt to justify the need for genetic conservation, and that training in evolutionary genetics and ecology be provided for resource managers and decision makers.

The Consultation recommended that aid organisations, development projects and resource management agencies should incorporate biodiversity considerations into project formulation activities, associated impact assessments, and in project implementation schedules. This should include adequate funding and the provision of expertise, where indicated, to enable proper attention to genetic resource issues before, during and after the project, as necessary. Furthermore, the Consultation recommended the monitoring of biological diversity and genetic diversity and oversight of activities affecting these resources. Included in this facility should be adequate attention to existing codes of practice in relation to activities, such as stocking, species introductions, genetically modified organisms, habitat rehabilitation, fishery management and aquaculture.

The Consultation also recognized that sustainable utilization and simultaneous conservation of aquatic animal genetic resources require sharing benefits and costs derived from the resource between users and donors. Therefore, the Consultation recommended that recognition must be given to the rights of local communities, farmers, fishers, and indigenous people. The Consultation recommended that intellectual property rights, particularly patenting, should receive special attention.

The Consultation noted the role of FAO and other international organizations in regards to aquatic conservation and recommended that these organizations should continue to gather and disseminate information, provide fora for consultation, provide advice to member countries, and coordinate action.

Recognizing the value of non-governmental organizations in aquatic resource conservation, the Consultation recommended that they should contribute advocacy, funding and, as appropriate, implement novel conservation strategies.

Furthermore, in light of the fact that industries may both benefit from and jeopardize natural resources through development, the Consultation recommended that industry and the private sector practice responsible development, and as appropriate, contribute funding to conservation efforts.

The Consultation recognized that there are many different end-users of information on genetic resources and biodiversity: policy makers, researchers, technicians, private sector companies, fishers, farmers and others. The Consultation further recognized that the information needs of these users are different. For example, a farmer may simply want to know where to obtain a certain breed of fish and scientists need access to scientific literature. There are several ways that they can attempt this (international, non-governmental, or governmental organizations, commercial buyer's guides, and bibliographic databases such as Aquatic Sciences and Fisheries Abstracts, Current Contents), but not all of these are well-used or affordable in developing countries. Realizing the importance of baseline genetic data and basic resource inventories and distributions in any decision/management process involving genetic diversity, and acknowledging Chapter 15 of Agenda 21 that cites the need for improved inventories of genetic and biological diversity, the Consultation recommended FAO's participation in and expansion of international inventory systems or databases on genetic resources. The Consultation acknowledged the difficulty in procuring basic useful information on aquatic organisms and commended the efforts of those attempting to remedy the problem, for example, the ICLARM-FAO multispecies database "FISHBASE" (Pauly and Froese 1991) . Because this field and the amount of data are expanding very rapidly, on-line accessing of FISHBASE and other databases will be necessary in the future. The Consultation recommended that the arrangements made with regards to databases for crops and livestock by FAO and the Consultative Group on International Agriculture Research (CGIAR) should be investigated to consider their applicability to fish, molluscs and crustaceans and other aquatic biota.

The Consultation appreciated the value of networks, newsletters, and other types of information exchange, but stressed that in order to facilitate utilization and conservation and aquatic genetic resources, concerned people must interact. Therefore, the Consultation recommended the exploration of mechanisms that will bring individuals together physically. Such mechanisms may include, but would not be limited to, workshops, scientific exchange programmes on national, regional, and global levels, and training programmes.

The Consultation noted with alarm that despite the recent importance placed upon biodiversity issues by governments there continues to be attrition of the institutions playing a fundamental role in supporting efforts in this field. In particular, the Consultation regretted the tendency to erase important collections of biodiversity in museums of international importance, through inadequate funding, and the disfavour into which classical taxonomy has fallen. The Consultation acknowledged that whilst modern techniques to evaluate biodiversity at a genetic level have made significant contributions, classical taxonomy still remains a fundamental and important task. Throughout all aspects of work relating to biodiversity, whether of an applied or pure nature, museums for the storage of biodiversity benchmarks are essential, as is the continuity of expertise in such fields. The Consultation stressed that methods enabling the direct genetic assessment of archived material are also being developed adding further weight to the argument for its preservation.

Similarly, the Consultation recognized that zoos and other institutions have an important role to play in the preservation of important biota in live gene banks, breeding programmes for release into the wild and especially through education of the general public. Therefore, the Consultation recommended that the importance of museums, zoos and other institutions of national and international standing should be acknowledged through adequate funding support in order for them to preserve the invaluable collections already in existence, improve upon these, ensure their effective critical role for the future and play a lead role in education.

The Consultation acknowledged that within the last decade, the array of technical tools used by population geneticists (e.g. DNA markers, immunotechniques) have advanced dramatically in number, sensitivity and ease of use. These developments have contributed to a rapid advancement of empirical knowledge and enhancement of population genetic theory. The Consultation recommended the application of these advances to real problems of aquatic resource management.

The Consultation recognized that knowledge of natural systems and molecular, quantitative and population genetics will never be perfect, but recommended that effective conservation action should be taken with knowledge presently available or easily gathered. In addition, the Consultation recognized the continued need for basic research and specifically recommended studies on relating an organism's genotype to its phenotype and therefore, to the performance and appearance of aquatic animals. The Consultation also recommended research on the causes and mechanisms of damage to aquatic animal genetic resources due to human activities and how to minimize impacts. In light of the vast, but unequally distributed, knowledge and expertise on conservation genetics, the Consultation recommended that scientists should provide expertise and training in conservation and genetic research in order to facilitate the above actions and research.

The Consultation further recommended the establishment of local definitions for natural units of conservation interest, the conservation objectives for such units, and the conservation strategy and plans for each unit. The Consultation noted that although standardization of nomenclature is not complete, operational definitions of key concepts do exist and incomplete clarity at this conceptual level should not be allowed to preclude application of genetic principles for purposes of conservation. The Consultation recommended increased efforts to standardize nomenclature on aquatic genetic resources, preferably in harmony with the nomenclature used by terrestrial plant and animal scientists.

Toward increased clarity in communication, both during the Consultation and in other fora where aquatic genetic resources are discussed, the Consultation recommended the adoption and standardization of the terms, population, stock, evolutionary significant unit (Waples 1991), intrinsically significant unit (Preamble Biodiversity Convention, UNCED 1992b), and species. These terms are defined in Annex D. Noting the difficulty in precisely defining terms, such as genetic diversity, and further noting that operational and conceptual definitions of such complex terms exist, the Consultation recommended adopting workable definitions now that will be refined at a later date.

The Consultation recommended that FAO promote appreciation that a wide variety of human activities can have effects on the conservation of aquatic animal genetics resources, and in particular that off-site pollution and environmental degradation can have effects on geographically distant ecosystems (e.g. global warming, air pollution, acid rain, downstream habitats in river drainages).

Natural populations

Recognizing that the increase in human population exerts a growing pressure on natural populations and that increased attention and effort is needed to conserve genetic resources of natural populations, the Consultation recommended that natural gene pools and their special features should be considered as valued and useful resources to be conserved and utilized. Specifically, the Consultation recommended the undertaking of actions promoting the maintenance of existing levels of genetic diversity, the conservation of viable populations, and the preservation of the evolutionary potential of species. The Consultation further recommended that genetic conservation of natural populations should be considered within the dynamic field of population genetics.

Aware that only limited numbers of aquatic species are cultivated or harvested, that new species may be harvested or farmed in the future, and that ecological interactions of many species are required for proper community function, the Consultation recommended that conservation efforts should consider not only those species used for food or of economic importance, but other ecologically important species as well.

The Consultation acknowledged that the primary threat to natural aquatic genetic resources is habitat destruction and degradation and recommended the identification and protection of key areas of aquatic diversity and ecological refuges. The Consultation further recommended that historically important habitats should be restored or rehabilitated. The Consultation stressed that the preferred strategy for protection of natural aquatic gene pools is in situ conservation. However, ex situ conservation involving propagation and gene banking may have supplemental roles to play. The Consultation recommended the intervention of in situ and ex situ gene banking in conservation efforts before aquatic resources of an area or of a species are critically endangered.

Aware of the recent scientific and technological advances in regards to genetically modified organisms (GMOs), and also aware of the advantages and risks involved with utilizing genetically modified organisms, the Consultation recommended that effective containment measures be taken during research and testing of such organisms. The Consultation also recommended research into quantifying the alteration caused by genetic modification not only of targeted traits, but also of non targeted traits. The Consultation recommended the promotion and development of field testing of genetically modified organisms to evaluate performance, fitness, and their impact mechanisms. The Consultation further recommended that quantitative risk assessment and risk management be conducted when evaluating genetically modified organisms and that the burden of proof for safety of application of GMOs is on the party requesting the use permit.

Introductions and transfers

In accordance with the World Fisheries Congress (Athens, Greece 1992) and the International Commission for the Exploration of the Sea (ICES), the European Inland Fisheries Advisory Commission (EIFAC) and several FAO Regional Fishery Bodies, the Consultation noted both the potential benefit and harm of species introductions and transfers. The Consultation recommended adherence to the ICES/EIFAC Codes of Practice and Manual of Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms (Turner 1988). The Consultation appreciated the structure and spirit of the Code, but noted that many of the sections, including the section labelled "Genetics" were ambiguous or difficult to comply with in developing countries.

In this regard, the Consultation recommended amending the Code by expanding and clarifying certain sections, including the section on genetics. The Consultation noted that although recently, attention to the Code has increased, the Code has been utilized by only a very few development projects that have introduced or are planning the introduction of aquatic organisms. The Consultation noted that some countries, especially those in the developing world, encounter specific problems regarding their technical ability to apply the code and access to expertise in this field. The Consultation felt that the use of the Code could be facilitated and therefore, recommended the publication of a simple, easy to understand user manual that would demonstrate how to practically perform the tenants of the Code. Suggested protocols for quarantine should give more attention to practicalities and remove some inconsistencies that occur the existing version. The Consultation further recommended that protocols for risk assessment for socioeconomic and biological considerations should also be included.

Furthermore, the Consultation noted that the Code may not be implemented due to culpable negligence of various groups. The Consultation recommended continued education with regard to utilising the code should occur. The Consultation recommended the promotion of a more responsible attitude towards fisheries and aquaculture management actions involving introductions/transfers, especially in response to the clearly identified importance of the conservation of biodiversity in aquatic ecosystems.

The Consultation also recommended the establishment of an international advisory or steering committee that would serve to help implement the spirit of the Code. The Consultation stressed that this international group, as well as the Code and supporting publications should be seen as promoting the utilization and conservation of aquatic genetic resources and should not be seen as a hindrance to development. Furthermore, the body and Code should be sympathetic to the practical constraints facing many countries.

Although it was acknowledged that hybridization between introduced or transferred species and resident ones can have harmful effects on the latter, the Consultation recommended that other changes in the genetic resources resulting from such introductions or transfers be considered also. For example, an exotic species or strain of aquatic organism, through competition and/or predation, may selectively remove an age class, life history stage, or subpopulation of resident populations, thereby reducing genetic variability or changing the population structure of the local species. Furthermore, to assess accurately both the impacts of introductions and transfers on resident species and the mechanisms for any impacts, the Consultation recommended the compilation of genetic and demographic data on resident species likely to be affected, prior to any introduction or transfer.

The Consultation further acknowledged that in developing country situations the financial resources available to execute adequate safeguards regarding the introduction/transfer of organisms may be inadequate. In response to global concerns over biodiversity issues, the Consultation recommended that aid organisations should assist in this matter by the provision of adequate funding in projects likely to involve such considerations.

Realizing the potential value in predictive models of biological interactions between introduced and resident biota at an ecosystem level, and that broader, seemingly peripheral aspects of socio-economics and alternative actions to introductions are necessary for complete modelling studies, the Consultation recommended the development and application of practical models on risk assessment and management, as well as ecological interactions.

Noting controversy over the optimal genetic composition of a stock of introduced organisms, the Consultation recommended basic research on genotype environment interactions and on the fitness value of genotypes. The Consultation recommended that this research should involve controlled experiments on genetic tagging, population monitoring, and population genetic modelling.

The Consultation acknowledged that aquaculture is now the major source of introductions and transfers of organisms and that it is rare for cultured species to be entirely confined within aquaculture enclosures; escapes are generally inevitable. The Consultation recommended that the concept of organisms moved from region to region through aquaculture are introductions or transfers into the wild, unless proven otherwise, should be adopted in all aquaculture management activities. The Consultation further recommended that this approach should be promoted through education and, where necessary, appropriate legislation. In particular, greater attention to existing codes of practice relating to the introduction or transfer of aquatic organisms (which are already intended to encompass organisms utilised for aquaculture purposes) should be promoted within the aquaculture sector.

The Consultation appreciated the difficulty of tracing the history of introductions, the organisms involved, their genetic composition, the purpose of introduction and their origin. In this regard, the Consultation recommended that the movement of all introduced or transferred organisms should be fully and properly documented and such data deposited in a suitable database for this purpose (e.g. FISHBASE) which should be regularly updated.

Stocking and enhancement programmes

Recognizing the importance of local adaptation of natural populations and their local acceptance by indigenous people, the Consultation recommended the use of native stocks, were possible, for enhancement or culture operations.

Aware of the necessity in certain cases of stocking and aquaculture enhancement projects, the Consultation recommended that both the recipient and potential source stocks be characterized genetically. All aquaculture activities involving exotic species or the significant release of native species, including escapes, into surrounding environments, activities involving ranching and purposeful introductions should involve the collection of genetic data on both the inoculated material and the relevant components of the wild/feral biota in the ecosystem in question. The Consultation noted that there are certain kinds of fishery and aquaculture programmes which entail significantly greater risks to biodiversity than others. In particular, introduction of exotic species, enhancement of wild stocks with hatchery stocks, and cage culture in large lakes and seas. In these instances, the Consultation recommended that genetic characterization of the stocking material used, and of closely related populations in the open water into which may receive these stocks, should be considered as a part of the project cost. The Consultation recommended that these activities should be promoted with a view to both elucidating and monitoring the effects of such activities on wild/feral stocks.

The Consultation realized that practical constraints usually exist in determining the extent of the problems arising from stocking, not the least of these is the inadequate information that exists on the genetic composition of wild or feral biota prior to stocking. The inability to distinguish between organisms of different origin in the wild is a major constraint in determining and monitoring the effects of stocking. To assist with technical investigations the Consultation recommended the

use of genetically marked stocking material should be considered as a minimal requirement in all stocking activities and should be encouraged to enable stocked biota to be distinguished from wild or feral biota.

Aware of the fact that stocking programmes have the potential to enhance the variance in reproductive success of a segment of a population, such that after mixing of hatchery and wild components, the effective population size of the enhanced population is less than it was prior to stocking, the Consultation recommended that genetic marking programmes should guard against exacerbating this effect. Therefore, the Consultation recommended that genetic marking programmes should incorporate measures to maximize, to the extent possible, effective population size in both hatchery and enhanced populations.

The Consultation acknowledged that stocking can involve greater impacts on genetic diversity than introductions/transfers, according to circumstance. However, the Consultation also noted that the existing EIFAC/ICES code of practice relates specifically to the initial introduction or transfer of aquatic species and not to stocking. Therefore, the Consultation recommended that a code of practice should be developed in relation to the biological (including genetic) consequences of stocking.

The Consultation recommended that the genetic differentiation among populations should be maintained by restricting allowable levels of gene flow, which would include transfers and the breaking down of physical reproductive isolating barriers. The Consultation recommended that propagation and hatchery management should follow sound genetic principles to minimize unwanted hybridization, introgression, inbreeding and loss of genetic variability. In order to facilitate transfer of germplasm, when necessary and as appropriate the Consultation recommended the use of cryopreserved materials.

Fisheries and fishery related activities

The Consultation identified two broad areas of concern: 1) the effects of fishing and fisheries management practices on genetic resources, and 2) the effects of non-fisheries activities that impinge upon genetic resources of value to fisheries. Hence, the Consultation noted that fisheries can be regarded as either the culprit or the victim of disturbances to genetic resources. The Consultation recommended the application of genetic principles to fishery regulation and management in order to sustainably harvest the resource, to conserve the genetic structure of the impacted population, and to preserve the evolutionary potential of the aquatic communities. The Consultation reaffirmed the importance of in situ conservation and stressed that appropriate fishery management, based on sound genetic and demographic principles, is a vital and viable form of in situ conservation.

Further acknowledging that overexploitation represents a threat to aquatic genetic diversity, the Consultation recommended the regulation of harvest to promote sustainability and the development of selective fishing techniques and gear technology to minimize by-catch. The Consultation emphasized that the regulation of the harvest of mixed stock fisheries should strive to protect the most vulnerable stocks.

Realizing the complex nature of the effects of fishing activities, in that they have the potential to reduce the numerical size of fish populations and alter the genetic structure of targeted and non targeted populations, and that these populations exist within larger ecological communities, such that changes in abundance may change community interactions, the Consultation recommended the evaluation of the following questions to examine the likely impact of interventions associated with fishing on aquatic genetic resources:

(1) What is the structure of genetic diversity in this species/population?
(2) What is the range of human interactions with this species/population?

(3) What are the biological consequences of these interactions for this species/population?
(4) How will these interactions affect the maintenance of genetic diversity?
(5) What steps should be taken to prevent loss of genetic diversity?
(6) What field tests are needed to evaluate the effectiveness of these preventive measures?

Although the Consultation noted the potential impacts of fishing and exploitation on the genetic resources of targeted and non-targeted stocks, the Consultation acknowledged that few examples or controlled experiments actually document the real impacts of these activities. For example, the classical effects of overfishing and some selective fishing, i.e. reduced size of fish, smaller size at maturity, early maturity, rapid early growth, appeared to reverse themselves after cessation of the fishery. Therefore, the Consultation recommended controlled fishing experiments on unexploited or lightly exploited populations likely to become heavily fished to test the null hypothesis that fishing has no effect on their genetic structures; the similar null hypothesis should also be tested, that fishing has no effects on the other components of the ecosystem with which these fished populations interact.

The Consultation acknowledged that, in most cases, essential data on genetic resources of impacted populations is not available and therefore, the Consultation recommended the collection and utilization of baseline genetic data. The Consultation further acknowledged that collection of genetic data must proceed together with the application of these data to fishery management. The Consultation noted that many fishery managers are unaware or refuse to accept that fishing activities can disrupt the genetic diversity of target and/or non target species/stocks. In this regard, the Consultation recommended the production of a publication, aimed at fishery managers and government agencies, outlining (in simple, non-technical language) the potential and documented genetic impacts of fishery and aquaculture activities.

The Consultation noted the capture of ornamental fishes represents a special type of fishery which can impose a real threat to conservation of genetic resources since such fisheries can concentrate on species which are already rare. Therefore, the Consultation recommended that the harvest of ornamental fish also be subject to genetic resource management and conservation.

The Consultation noted that activities associated with rehabilitation of fisheries and aquatic communities may also affect aquatic genetic resources. Although the aim of such activities is to improve the resident fishery, stable communities evolve over time and cannot be created de novo and baseline data on genetic and biological diversity is often lacking. Therefore, the Consultation recommended that databases and networks that document community composition, inter- and intra-specific interactions and intraspecific genetic variation need to be established for future access in fishery rehabilitation programs.

The Consultation recommended that a major goal of fisheries rehabilitation should be to maintain the evolutionary potential of the population and efforts should be promoted to maintain genetic continuity of vulnerable species/populations through, for example, cryopreservation of genetic material and the development and maintenance of aquatic reserves for natural and/or artificial propagation of species/populations prior to reintroduction. The Consultation felt that the option to rehabilitate ecosystems, and the growing importance of this activity, supports endeavours to preserve genetic resources. The Consultation stated that preservation of species/populations through last resort methods (e.g. gene banking) is not, as often stated, a futile exercise.

Although the Consultation agreed that habitat degradation and destruction seriously affect fishery genetic resources, the Consultation thought this topic too broad to discuss in detail during the Consultation; the Consultation highlighted it as an important issue. The Consultation endorsed the strategies and articles contained in other recent documents on biological diversity, such as the Convention on Biological Diversity and Agenda 21.

The Consultation noted that the fisheries sector is usually the end users of aquatic habitats and resources. For example, agricultural and forestry activities can impact fisheries, but such

considerations are often outside the considerations of the agriculture and forestry sectors. The Consultation recommended that all development proposals that can impact aquatic habitats and aquatic organisms should incorporate in their assessments due attention to aquatic genetic resource considerations. In particular, aid-funded projects in all sectors should incorporate aquatic biodiversity considerations at the planning stage.

Furthermore, the Consultation agreed that FAO was well placed to make significant contributions in these respects since it is one of the few institutions combining fisheries, agriculture, forestry and other sections. In this regard, the Consultation recommended increased co-operation and collaboration between these sections regarding the maintenance of aquatic genetic diversity. For example, a discrete field project to specifically develop integrated management systems for a river basin, coastal area or mangrove ecosystem would be very beneficial.

The Consultation recommended formal recognition of the importance of the traditional fishing activities of indigenous people. Included in this sector can be subsistence, non-commercial and non-formal activities. The Consultation noted that such activities are not restricted to the developing world or the tropics. For example, the traditional exploitation of salmon stocks by indigenous North American Indians would fall into this category, as would the traditional exploitation of sturgeon in European waters. The diversity of resources exploited, and their geographical range, can be extensive in this informal sector. In addition, most traditional knowledge of genetic resources operates at this level. The Consultation remarked that all too frequently, non-formal activities are ignored in development plans, partly due to inappropriate prioritisation and partly through ignorance (lack of data). Whilst catches per individual may be small, often, very large numbers of fishing individuals are involved. Coupled with the exploitation of a wide diversity of resources, generally based on natural stocks, and the extent of local knowledge of such resources, the Consultation acknowledged that this sector is much more important than is usually apparent. The Consultation felt that recognition of the importance of this sector, and basing actions upon this, can facilitate the conservation of aquatic genetic resources. The Consultation stressed that these resources are being utilised now as opposed to having some intangible future value. The Consultation regretted that all too often the lack of data on such activities promotes an attitude that they are not important.

Therefore the Consultation recommended that countries should be encouraged to obtain quantitative and qualitative data on traditional and non-formal fisheries activities, knowledge, and the genetic resources upon which these are based. This can be most effectively achieved by incorporating such considerations into existing socio-economic, demographic and other census programmes. The Consultation further recommended that where practical, countries should be encouraged to incorporate data for traditional, subsistence and non-formal sector catches into the FAO fisheries statistics.

The Consultation recommended that the policies and actions of governments, international organisations and other major institutions should give due regard to the importance of traditional/non-formal fishing activities both in socioeconomic and genetic diversity terms. In particular, the Consultation stressed that such activities should be deemed important unless appropriate data indicate otherwise.

Aquaculture

The Consultation acknowledged that the application of genetic principles to aquaculture is still far behind the crop, agriculture or animal husbandry sectors. The Consultation realized that some of the reasons for this situation in aquaculture are due to only very recent intensification of aquaculture practices and the low level of domestication of aquatic species, as well as the fact that the majority (approximately 90%) of the production from the aquatic environment comes from fisheries. The Consultation recommended that genetic principles should be applied to aquaculture

projects as a way to increase production and to conserve genetic resources for future applications.

The Consultation noted the importance of socio-economic expertise in formulating recommendations concerning genetic resources in aquaculture and the likely impacts of new technologies on different end-users. In this regard, the Consultation regretted the lack of such expertise in its participants and recommended that further discussions or consultations be convened which would include such expertise.

The Consultation recognized that while significant research on selection, genetic management and population genetics has been carried out for several species of finfish, such as carps and trouts, the results have not yet been widely applied in breeding programmes to benefit fish farmers in rural areas or the developing world. The Consultation commended the exceptions to this generality, such as carp breeding programmes in Eastern Europe and China. The Consultation was further encouraged by recent research on tilapia genetics, but noted that this research has not yet reached a stage where it has had an impact on tilapia culture.
The Consultation noted the uneven application of genetic research effort to aquatic species (Annex C) and therefore, recommended basic research on quantitative and population genetics on additional aquatic species.

The Consultation noted that in the application of quantitative genetics and animal breeding science to aquaculture, new methods and standardized protocols are needed. The Consultation recommended the establishment of control lines or other standardized methods of comparison among strains or other Operational Taxonomic Units (OTUs). Ideally a control should be completely stable, for example a cross between two inbred lines. The Consultation conceded that such a reference stock may be quite costly to produce and maintain and it is perhaps doubtful that breeding programmes in developing countries would readily develop such stocks.

The Consultation suggested alternative approaches in the establishment of control lines which would form a hierarchy with respect to lower costs coupled with lower stability. The Consultation recommended the following with which to compare new strains:

(a) half-sibs that are produced by crossing dams with cryopreserved sperm from the original stocks (or androgenetic fish if available); or

(b) randomly mated fish from the original stocks; or

(c) the current stock(s) that are widely used by farmers.

The Consultation stressed that the most important point is that all breeding programmes must have adequate control lines for comparison. The choice of controls should be made based upon practical considerations and available resources. The Consultation recommended that controls must be well-maintained and accessible; for example keep adequate supplies of frozen sperm or numbers of control fish. The Consultation noted that controls are needed for all species that are widely cultured - currently about 20 species of carps, catfishes and tilapias in inland waters.

The Consultation recommended the establishment and cataloguing of the conservation value of a given population of aquatic organisms. The Consultation realized that this term has not been precisely defined, but depends upon the population's or stock's culture performance characteristics and its genetic distance from other populations or stocks. The Consultation acknowledged that the determination of the conservation values of operational taxonomic units in aquaculture (strains, varieties, etc.) requires both population genetic evaluation as well as quantitative trait assessment by standardized protocols. The Consultation recommended that both the public and the private sector should contribute data to determine conservation value. Private sector efforts reflect economic interest and will usually be directed towards producing and conserving breeds for specific purposes, whereas public sector efforts may incorporate ecological

interests and will usually be directed towards more general conservation and re-establishing endangered resources.

The Consultation noted that selective breeding, hybridization and genetic management (chromosome-set manipulations, gene transfer, etc.) are the main strategies for genetic improvement. The Consultation recommended evaluation on whether and how to combine these strategies in breeding programmes.

The Consultation acknowledged that the choice of strategy for genetic improvement can have far reaching effects on the structure of fish hatchery operations and farming systems. For example, a system geared to production of F_1 hybrids or crossbreeds will have different structure and management requirements than those needed for propagation of fish breeds developed by selective breeding. The Consultation recommended that all those concerned with fish breeding programmes should pursue strategies to conserve biodiversity, not just increase performance with respect to commercial traits. Furthermore, the Consultation recommended that the impact of such strategies should be monitored both as to their impact on biodiversity and on socio-economic structure of the local community. The Consultation regretted that such monitoring programmes have not been common.

The Consultation noted that it is not yet clear how the seed supply sector will develop in different countries, i.e. the balance between public and private sector hatcheries and the degree of centralization. Large centralized hatcheries usually facilitate better broodstock management and quality control and small hatcheries may be non-viable unless adequate credit and/or incentives are given to breeders. Most countries have tended to rely on a small number of large hatcheries. However, the Consultation realized that small-scale hatcheries exist (for example in Indonesia and Thailand) and a market demand for diverse breeds could provide some economic incentives for decentralized hatcheries. The Consultation noted that, at present, this applies to only a few species with an extensive breeding histories that have produced much stable intra-species diversity (e.g. common and Crucian carps in China), but that in the future it could apply on a wider front. The Consultation noted that there could be incentives for farmers to raise their own seed, more so than in agriculture, and therefore, the Consultation recommended basic research on different seed supply scenarios and their effect on genetic diversity, farm level diversity and socio-economic impact.

The Consultation recommended that the potential to maintain genetic diversity in the context of the control of the transfer of aquatic species by localized seed production should be considered. Breeding programmes should consider this and its implication for conservation of biodiversity. Therefore, the Consultation recommended that the planning and execution of breeding programmes must consider the likely evolution of the structure of the seed supply sector and must adopt strategies for genetic improvement that will not only bring genetic gain to benefit farmers but will also conserve genetic and biological diversity.

The Consultation recognized that to conserve genetic resources requires documentation and evaluation, and therefore, recommended collaborative efforts between developing and developed countries to determine conservation values. Developing countries are the sites for collection, evaluation of material and breeding programmes. Developed-country institutions can assist by analyzing and interpreting data from tissue samples, computing, brokering information and assisting with certification and banking of material. The Consultation noted that well-equipped international laboratories in developing countries can also contribute - as do the CGIAR centres for crops and livestock. In this regard, the Consultation recommended that FAO should strive to facilitate such collaboration among developing and developed countries.

The Consultation recommended that species databases should contain clear information on breeds, where they can be obtained, and all other genetic information available. The Consultation further recommended that FAO and other international agency projects should foster resources and activities which make genetic information on relevant species available at the national level.

The Consultation noted the potential and actual problems of genetic homogenization and loss of genetic and biological diversity associated with the widespread use of one breed of cultured fish. The Consultation recommended the application of international Codes of Practice on transfers of aquatic organisms when considering such widespread use. The Consultation stressed that in the case of high performance breeds, it is not the high performance breed or the selection programme per se that produced it that has been responsible for a loss of genetic diversity, but rather it is the wide spread acceptance of the high performance breed, the displacement of local breeds in the farmers ponds and market place, or the escape of the high performance breed and its subsequent interactions with natural populations that have caused a reduction in genetic diversity.

The Consultation noted several misconceptions and controversies concerning the effects and genetic changes on a population of organisms subjected to selection. The Consultation recommended further long term research on the genetic changes and on the persistence of genetic gain achieved through selection programmes.

The Consultation identified four factors that threaten the genetic diversity in cultured populations and recommended that management activities be undertaken to ameliorate these effects:

1) small size of cultured populations leading to genetic drift, inbreeding and strong selection, (small size of cultured populations can also result from inbreeding and strong selection as well as from variance in reproductive success),

2) inadvertent and natural selection in captive populations,

3) economic displacement of locally adapted strains or populations by widespread use of high performance breeds, and

4) lack of information on the Conservation value of local populations.

The Consultation acknowledged that aquaculture has environmental impacts and these can affect natural aquatic genetic resources. The Consultation recommended that the benefits of aquaculture be weighed against the environmental costs of aquaculture development. The Consultation suggested reasonable constraints on aquaculture development, and that aquaculture development should be environmentally sustainable by not threatening the scope for further adaptive change.

The Consultation stressed that the training of good scientists at a high level is key to accelerating and disseminating the application of genetics in aquaculture, which is at an early stage. The Consultation further acknowledged that since limited resources are currently available in developing countries for genetic research in aquaculture, this training will serve a number of purposes: creating a reservoir of knowledge which can be immediately applied to local problems, which can be used when more advanced facilities become available, and which can be passed to on to others through training. Thus, the Consultation recommended a realistic balance between training in high technology (for example molecular genetics) and approaches that are more immediately applicable and relevant to farmers' needs in developing countries.

The Consultation noted that split Ph.D. programmes, for which formal training and appropriate supervision are provided by an institution with advanced scientific capabilities and for which the dissertation topic and field work are relevant to, and carried out in the home country, is one way to provide this balance. This requires close collaboration between the host institution, the trainee and the home institution. The Consultation recommended that FAO and donors supporting high level training facilitate this collaboration, for example, by linking split Ph.D. programmes to ongoing field projects. This approach builds up the human capacity to carry out research and to provide training in aquaculture genetics relevant to developing country situations. The Consultation stressed that training should be relevant to the trainee's home situation and

should benefit the home institution. The Consultation suggested that such training should, when possible, be linked to donor-supported aquaculture projects.

Policy and regulation

The Consultation noted that although conservation and/or utilization policies for aquatic animal resources exist in some states, and some regional and cooperative efforts have been initiated, comprehensive and workable general policies or mechanisms to resolve conflicts that may arise from the utilization or conservation of the resource, are lacking for global aquatic genetic resources. The Consultation acknowledged and appreciated the achievements of the Commission on Plant Genetic Resources, the Panel of Experts on Forest Gene Resources, and the Expert Consultations on the Management of Global Animal Genetic Resources. However, the Consultation recognized that aquatic animal genetic resources are sufficiently different from those of other taxonomic groups and therefore, recommended that specific attention be given to the aquatic sector.

The Consultation sought to provide a framework for the development of policy and legal instruments that will promote cooperation to conserve and use aquatic animal genetic resources. The Consultation recommended that the framework should include general principles which governments may follow in developing national laws and regulations, formulating policy on shared germplasm resources, and engaging in international cooperation. The Consultation recommended that policy be formulated that addresses a number of problems, consisting at least of the following items:

the rights and needs of communities of users and donors to ensure both that the benefits they obtain from aquatic animal genetic resources are not undermined by their distribution to others, and by the use of this germplasm by others now or in the future, and that there be a means of compensation for their contribution;

the collection of germplasm for the purpose of using or transferring it to another country, be undertaken with the knowledge and approval of the donor country and local communities;

studies of aquatic animal genetic resources involving use of *in-situ* populations should have full cooperation of the host country;

both the benefits of aquacultural development and the conservation of the germplasm in question should be considered in the siting of aquaculture operations in proximity to *in-situ* populations of aquatic animal genetic resources;

defining acceptable conduct and the obligations of collectors of germplasm, including scientific terms of reference for collection;

protocols for the exchange of information during and following collection, on the conservation, management and evaluation of the germplasm with the aim of promoting conservation, both *in-situ* and *ex-situ*;

ways in which recipients and users of collected germplasm may pass on the benefits derived from the use of the germplasm, and information from genetic studies, to the donor/host country scientists, local communities, farmers, fishers, and indigenous people;

the importance of the idea that one party be able to gauge the conduct of others with the aim of promoting effective cooperation;

the development of appropriate guidelines or protocols for the safe transfer of germplasm, and that these be exchanged internationally;

and the creation of guidelines that governments may find useful in developing national laws and regulations or formulating agreements.

The Consultation recommended that FAO use the most appropriate means to promote and continue the development of policies for aquatic animal genetic resources, as well as the appropriate international and national legal instruments. Further refinement of policy for aquatic animal genetic resources will require additional expert consultation on policy and legal matters *per se* and should include representation from user and conservation groups. Special attention should be given to conflicts between conservation and exploitation, to the conservation of genetic diversity of cultured stocks, and the relationship between conservation and various forms of genetic manipulations.

The Consultation further recommended that FAO draw attention to the need to identify and protect "hotspots" of aquatic animal genetic diversity and other geographical areas that may contain substantial unknown diversification of aquatic animals, to avoid loss of genetic diversity before proper surveys may be carried out. The Consultation noted that specific measure have not been taken to protect important or potentially important areas or ecosystems that have not been surveyed.

The Consultation recommended that FAO encourage the review of national and international laws and regulations related to fisheries to include the protection of aquatic animal genetic diversity as well as the sustainability of fisheries harvest. The Consultation recommended that the enforcement of adequate existing laws and regulations should also be encouraged.

The Consultation noted that the effects of the implementation of the present laws and regulations of fisheries on the diversity of aquatic animal genetic resources are poorly understood. Unpredicted or unintended changes or collapses in harvested populations often occur. The Consultation noted that this is partly due to the inadequacy of the laws and regulations in maintaining vital properties of the populations and partly due to inadequate enforcement of the laws and regulations. The Consultation appreciated that the aim of the laws and regulations are often other than the conservation of aquatic animal genetic diversity (e.g. to maintain or maximize desired outputs in terms of food or industrial raw materials). Therefore, the Consultation recommended that FAO promote research and surveys to identify the genetic impacts of harvesting stocks under existing fisheries laws and regulations and technology, and if needed other laws and regulations and alternative technologies should be concluded.

The Consultation acknowledged that aquaculture will be an increasingly important source of food production and that the necessary restriction on aquaculture activities should not become a barrier for the development of sustainable aquaculture operations. The Consultation further acknowledged that sustainable aquaculture operations will probably result in some environmental impacts; however no consensus has been achieved about the level of impacts that may be acceptable. Therefore, the Consultation recommended the definition and delimitation of acceptable environmental and socio-economic impacts. However, the Consultation stressed that this process should involve the local communities likely to be impacted, as well as government and development representatives.

The Consultation stressed that governmental involvement is essential for the formulation and implementation of laws and regulations concerning aquatic genetic resources. The Consultation recommended that FAO promote governmental participation in the implementation and enforcement of such laws and regulations to ensure the conservation and sustainable utilization of national aquatic animal resources, and facilitate interactions between governments to address the same problems when occurring in international or shared waters or problems associated with transfer of

aquatic organisms across national borders. It was further recommended that local communities and indigenous people become involved in the formulation, implementation and enforcement process.

The Consultation considered that a major problem in implementing policy may often be that responsible institutions or individuals have not been identified and acknowledged. This is often a crucial limitation for the application of the EIFAC/ICES code of practice on introductions and transfer of aquatic organisms. The Consultation recommended governmental involvement to clarify institutional and individual responsibilities that are not clearly defined today. The Consultation further recommended that a list of those people and departments responsible for policy and regulatory aspects of aquatic genetic resources be compiled and maintained in easy to access directories or databases.

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Annex A

SELECTED FAO ACTIVITIES IN GENETIC RESOURCE UTILIZATION AND CONSERVATION IN AQUACULTURE AND FISHERIES 1970 - 1990

1971	FAO Created ad hoc Working Party on Genetic Resources of Fish, Rome, Italy.
1976	FAO Technical Conference on Aquaculture, Kyoto, Japan.
1980	FAO/UNEP Expert Consultation on the Genetic Resources of Fish, Rome, Italy.
1981	FAO sponsored Report "Fish Genetics, selection, and Hybridization", India.
1983	Committee on Fisheries in Latin America (COPESCAL) "Conservation of Genetic Resources in Fish", Mexico City, Mexico.
1985	Committee on the Inland Fishes of Africa (CIFA) "Introductions of Species and Conservation of Genetic Resources", Lusaka, Zambia.
1986	Committee on Fisheries in Latin America (COPESCAL) "Introduced Species and Conservation of Fish Genetic Resources of the Region", Havana, Cuba.
1986	European Inland Fisheries Advisory Commission (EIFAC) Symposium on Selection, Hybridization, and Genetic Engineering, Bordeaux, France.
1986	FAO sponsored Fish cytogenetics and selection, India.
1987	Fish stock enhancement of the Sepik River, Papua New Guinea and application of the ICES/EIFAC Codes of Practice.
1988	European Inland Fisheries Advisory Commission (EIFAC) Technical Consultation on Genetic Broodstock Management and Breeding Practices, London, UK.
1988	European Inland Fisheries Advisory Commission (EIFAC)/International Commission for the Exploration of the Sea (ICES) "Codes of Practice and Manual of Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms".
1988	FAO sponsored Training Course in Coldwater Fish Culture; Genetics. Kalerdasht, Iran.
1988	Welcomme, R. "International introductions of inland aquatic species", FAO Fisheries Technical Paper 294. Rome, Italy.

Annex B

QUESTIONNAIRE ON THE UTILIZATION AND CONSERVATION OF AQUATIC BIODIVERSITY[1]

AQUACULTURE PROJECTS

DOES THE PROJECT INVOLVE GENETIC IMPROVEMENT OF CULTURED ORGANISMS BY:

a) selection programmes **10**	b) crossbreeding/hybridization **6**
c) transgenics **1**	d) chromosome manipulation **4**
e) genetic marking **3**	f) other **11 (strain introduction)**

DOES THE PROJECT USE A SYSTEMATIC BREEDING PROGRAMME?

YES	NO
6	**9**

HAVE PRECAUTIONS BEEN TAKEN TO PREVENT:

	YES	NO
a) inbreeding	**7**	**8**
b) loss of genetic diversity	**5**	**8**
c) hatchery/native interaction	**4**	**9**

THE VIGOUR OR PERFORMANCE OF CULTURED POPULATIONS DURING THE PROJECT HAS

a) increased	b) decreased	c) not changed
6	**2**	**7**

DOES THE PROJECT INVOLVE INTRODUCTION (a species not native to the area) OR TRANSFER (a species that is moved from one area to another within its range) OF AQUATIC SPECIES?

YES	NO
11	**6**

HAVE SPECIES CULTURED BY THE PROJECT BEEN

	YES	NO
a) purposefully released	**7**	**7**
b) accidentally escaped	**8**	**3**

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[1] Informal questionnaire distributed to FAO field projects working in the aquatic sector. **Bold** numbers in body of Annex refer to number of respondents indicating that response.

HAS ANY CODE OF PRACTICE BEEN FOLLOWED IN REGARDS TO SPECIES INTRODUCTIONS AND TRANSFERS?

YES	NO
2	10

FISHERIES PROJECTS

DOES FISHERY HAVE A KNOWN SUBPOPULATION OR STOCK STRUCTURE?

YES	NO
4	5

DOES ANY GENETIC DESCRIPTION OF HARVESTED POPULATION EXIST?

YES	NO
2	7

DOES PROJECT MONITOR OR ASSESS GENETIC STRUCTURE OF FISHERY?

YES	NO
2	7

EXPLOITATION OF THE FISHERY IS CONSIDERED

over	under	sustainable
4	0	3

DURING PROJECT, FISHERY HAS:

increased	decreased	remained constant
2	1	3

GENETIC IMPACTS OF THE PROJECT ON HARVESTED POPULATION HAVE BEEN:

favourable	adverse	unknown
1	0	3

GENETIC IMPACTS OF FISHERY ON THE HARVESTED POPULATION HAVE BEEN:

favourable	adverse	unknown
		5

TRAINING

WOULD YOU BE INTERESTED IN ATTENDING WORKSHOPS/TRAINING ON:

a) selective breeding 13	b) chromosome manipulation 6
c) transgenics 4	d) genetic stock id 10
e) hatchery management 13	f) genetic marking 3

WOULD YOU BE WILLING TO FUND ALL OR PART OF ABOVE WORKSHOPS/TRAINING?

YES	NO	Don't know
6	10	1

QUESTIONNAIRE ON THE UTILIZATION AND CONSERVATION OF AQUATIC BIODIVERSITY

Species of interest and location of FAO field projects that responded to Questionnaire

SPECIES	COUNTRY
Tilapia	Burundi
Eugerres brasilianus (Patao)	Cuba
Tilapia	Fiji
Tilapia	Ghana
Chinese Carp, Common Carp, Tilapia	Laos
Common Carp	Madagascar
Penaeus spp.	Mozambique
Tilapia, *Cichlasoma managuense, C. citrinellum*	Nicaragua
Rainbow Trout, Sea Trout, Huchen	Poland
Common Carp	Poland
Common Carp	Poland
Common Carp	Poland
Tilapia spp., Cichlidae, Cyprinidae, Clariidae, Schilbeidae	Southern Africa
Clarias spp.	Thailand
Indian Major Carp, Chinese Carp, Common Carp	Vietnam
Tilapia spp., *Micropterus salmoides*, Common Carp	Zimbabwe

Annex C

AN INDICATION OF THE APPLICATION OF GENETICS TO THE MAJOR CULTURED GROUPS OF FINFISH, MOLLUSCS AND CRUSTACEANS.

Number of publications (N) concerning genetics as determined from a search of ASFA database.

FINFISH			
Species group	**N**	**Species group**	**N**
CYPRINIDS		SALMONIDS	
Common carp	261	Trout	828
Indian Major carps	37	Salmon (and ayu)	925
Chinese carps	172	OTHER	
Other carps	283	Mullets	41
CATFISHES		Eels	62
Clariids	27	Seabasses	135
Ictalurids	105	Gobies	66
Silurids	14	Yellowtail	16
SNAKEHEADS	0	Milkfish	16
CICHLIDS		Sturgeon	110
Tilapias	413	Flatfish	192
Other cichlids	71	Coregonids	114
		Miscellaneous	135
MOLLUSCS		**CRUSTACEANS**	
Species group	**N**	**Species group**	**N**
Oysters	303	Penaeids	99
Clams	176	Macrobrachium	38
Scallops	35	Freshwater crayfish	37
Mussels	225	Crabs	265
Others (abalone, giant clam)	63	Artemia	97

Annex D

SOME OPERATIONAL DEFINITIONS PERTAINING TO GENETIC RESOURCES

Conservation. The active management of a resource such that the resource and all its facets can be utilized at the present and in the future.

Conservation Value. A value or assessment of an Operational Taxonomic Unit, population or species, that assists in determining the priority for preservation, development, improvement and research for the unit. The value is based on performance characteristics, genetic distance from other populations, strains, OTUs or species, and levels of endangerment and rarity. Conservation value could also be applied more broadly to ecosystems or to such things as traditional knowledge.

Evolutionary Potential. The potential ability of individuals within a species to evolve, i.e. adapt to change and proliferate. Components necessary to preserve the evolutionary potential within a species would be genetic resources, genetic diversity, and population genetic stock structure, such as isolation of subpopulations and migration or gene flow patterns.

Evolutionarily Significant Unit[1]. A genetic population/stock which is 1) genetically unique, 2) exhibits unique adaptation, 3) inhabits unique habitat, or 4) whose extinction would represent loss of an evolutionarily significant legacy.

Genetic Diversity. An integral component of biological diversity, that exists within a hierarchical frame of: genes, genotypes, populations, groups of related population (meta populations), and species. It is important to note that while the genes that characterize a species may be present in a population, it is the array of genotypes within the population that characterize the genetic diversity of the population and species. This is a crucial difference between genetic diversity and genetic resource. Thus, a hybrid population that contained all of the genes of the parental species would be similar to the parental species with regards to genetic resources, but their genetic diversity would be much different.

Genetic Resource. This general term encompasses the genes in, populations, groups of related populations, and in the species.

Intrinsically Significant Unit (Preamble UNCED Convention on Biological Diversity). A genetic population/stock which has social, economic, scientific, educational, cultural, recreational, or aesthetic value.

Operational Taxonomic Unit (OTU). The unit of research, study or management that is to be evaluated, preferably with regards to a control line. The OTU may be a strain, a population, a species, genetically modified organisms or hybrid organisms.

Population. A genetic term denoting a group of individual occurring at the same place and time which share a gene pool.

Species (Phenetic approach). A group of organisms sharing a gene pool and a unique combination of taxonomic characters.

Stock. A practical fisheries management term denoting a group of individuals for management purposes. A stock may comprise several species or several subpopulations, and should be defined by the user. A natural stock is not equivalent to an aquaculture stock.

[1]Waples, R. 1991. Pacific salmon, Oncorhynchus spp., and the definition of "Species" under the Endangered Species Act. Marine Fisheries Review 53: 11 - 22.

Annex E

ABSTRACTS

Preface

The purpose of the experience, information and background presentations was not to extensively review the literature on genetic diversity, for there have been numerous excellent symposia and reviews very recently, but rather to provide a common starting point for further discussions and recommendations on the utilization and conservation of aquatic genetic resources. The first four experience papers represented contributions from professionals from FAO Departments responsible for genetic resources of agricultural plants and animals, forestry, and legal aspects that will serve as excellent models on which to base fishery programmes. Each of these departments has adopted a specific strategy to deal with the complex issues of genetic resource utilization and conservation. These strategies range is complexity and formality from the group of experts that serve as an advisory body to the Forestry Department, the proposed Global Forum for Animal Genetic Resources, to the advanced Commission on Plant Genetic Resources and the International Board for Plant Genetic Resources.

The background presentation by Utter and Ryman demonstrated the practicality and potential of utilizing genetic markers and genetic stock identification in mixed stock fisheries. Although much of the application of genetic stock management has concerned salmonids, these authors provided a useful review of salmonid and other data on genetic management of fisheries and outlined techniques and strategies for their use on other species in various climatological zones.

The presentation by Altukhov reviewed effects of fishing on genetic resources primarily in the former Soviet Union. This review was important in that documentation of the real effects of fishing activities on genetic resources are not well known and may appear unexpected. The classic effects of selective fishing on a population, e.g. fast juvenile growth, smaller size at age of maturity were shown to reverse themselves during the several years of fishing cessation caused by the second World War. According to Russian data for Pacific salmon, selective fishing leads to the increase of biochemical heterozygosity of exploited populations, though an example from New Zealand marine fishery for Orange roughy shows a decrease in heterozygosity. Altukhov's review as well as the recommendations of the Consultation demonstrate that additional research is required in the area.

That China is also a country of vast genetic resources that are seriously threatened, as well as the world's leader in aquaculture production, was highlighted by Li. China's natural aquatic diversity and traditional inland and marine fisheries are threatened by the need to feed the most populous nation on Earth. Conservation strategies and proposals and international intervention were seen to be necessary in protecting China's resources such that the Country could maintain its primary position in aquaculture production.

Hedgecock provided a succinct survey of the advantages, current problems, and future prospects for methods to procure genetic data. The methods of genetic analyses, though well known to most of the participants, are expanding and at an ever increasing rate. Hedgecock pointed out that both money in the form of laboratory equipment, supplies, etc., and climatological zone will play key roles in designing sampling and analytical protocols. For example, to survey genetic diversity, one would focus on sub-population diversity in temperate latitudes where stocks and genetically differentiated populations are important, whereas, in the tropics sampling would concentrate on species differences because relatively more genetic diversity is partitioned among tropical species and relatively less is due to intrapopulation differences.

The importance of a balanced approach to biotechnology and genetically modified organisms was stressed by Hallerman and Kapuscinski. New genetic technologies are exciting and have the potential to tremendously assist in food production. However, Hallerman and Kapuscinski point out that there is still much basic research, experimentation, and evaluation that must preface the wide spread use of these technologies, especially in the developing world where substantial natural genetic diversity may be affected.

Harvey and Mace presented one of the new technologies that does have immediate use and facility in conservation and utilization of genetic resources, namely cryopreservation. These authors stated that possibilities of rebuilding weak stocks from cryopreserved sperm are now realities that will figure heavily in conservation efforts and lend justification for gene banks and other zoological collections. Combined with techniques to sex reverse fish and manipulate chromosomes during mitosis and meiosis, utilization of cryopreserved sperm is expected to increase in both the developed and developing world.

Haight provided an informative review of aquaculture and biological diversity in southern Africa. This area is of great international importance due to the resources available to help alleviate hunger that is wide spread. Actions to maintain elements of biodiversity must be balanced against the need for rapid economic development.

The two papers by Doyle and Eknath both discussed, although from different perspectives, breeding programmes and the role and effects of selection and genetic diversity in domesticated or semi-domesticated aquaculture stocks. The diversity of approaches in these two presentations highlight the wide range of prospects and options available in utilizing and conserving aquatic genetic resources. Eknath reported significant gains in the culture performance of Nile tilapia after only a few generations of combined selection. Doyle approached the subject from a more theoretical approach that utilized technologically advanced DNA fingerprinting and mathematical sophistication. Both approaches stressed monitoring and critical evaluation of breeding programmes.

A third paper dealing with quantitative genetics, selection and changes in genetic diversity was presented by Bentsen. This presentation highlighted the fact that basic research and standard usage of key terms are still needed to understand the complex relationship between genotype (allelic constitution) and genetic values (the effect of the genotype on the phenotype). Bentsen presented a quantitative genetic model that predicted little net loss in genetic diversity even following long periods of intense selection. In light of the fact that it is assumed that quantitative traits are controlled by a great number of genes, the selected individuals in a population or stock under selection will have similar genetic values, in regards to the trait under selection, but will normally have many different genotypes. Therefore, Bentsen proposed that genetic diversity is in fact maintained under selection because of the resegregation of genes between each generation. This will provide genetic flexibility in case of sudden shifts in selection pressure.

Some of the problems aquaculturists and resource managers encounter with nomenclature concerning genetic differentiation below the species level were presented by Bartley. Since the 1970's aquaculturists have requested a standard system of nomenclature. Borrowing from elements of some useful and not so useful definitions that have been applied to domesticated crops and livestock, Bartley proposed one system to designate strains in aquaculture. Although several systems of nomenclature are possible, some standardization was felt necessary with specific application to international strain registries or databases.

As in any international gathering, differences in experience and priorities lead to different ideas and interpretations of seemingly objective data. The conclusions and statements of the background papers represent the authors' professional point of view and should not be construed as the recommendations of the Consultation. Controversies should be acknowledged and treasured in that they demonstrate the need for scholarly pursuits with well designed experiments,

monitoring, and cooperation. The complete background and experience papers will be published in the Proceedings of the Expert Consultation on Utilization and Conservation of Aquatic Genetic Resources.

FAO Programme on Animal Genetic Resources (FI/EGR/92/4).

D.E. Steane. Agriculture Department. FAO, Rome, Italy.

Abstract

The paper discusses the development of FAO's work in Animal Genetic Resources. Animal in this context refers to domesticated species and breeds of livestock. The main thrust enacted from the cooperative work/meetings undertaken with the United Nations Environmental Programme (UNEP) since 1980. The development of a comprehensive literature on the main aspects of Animal Genetic Resources is discussed together with the cooperation and development of a World Animal Genetic Resources databank initially at Hannover, Germany. Recent developments and activities including a global breed survey, contributions to the United Nations Conference on the Environment and Development (UNCED) and Agenda 21, and an outline of a global programme on animal genetic resourse are described. In particular, the recommendations of the Expert Consultation on the Management of Global Animal Genetic Resources are outlined including the need for separate activities for Animal and Plant Genetic Resources. The implications of the activities and progress of the animal genetic sector are discussed in the context of Aquatic Genetic Resources. The need for rapid action versus the need for time for familiarisation with the topic of global aquatic gene resources are highlighted.

FAO Global System for the Conservation and Sustainable Use of Plant Genetic Resources (FI/EGR/92/5).

J. Esquinas-Alcázar. Agriculture Department, FAO, Rome, Italy.

Abstract

Man-induced alterations in many ecosystems have destroyed the habitats of many species, reducing the genetic diversity to the limits of tolerance. A greatly reduced genetic pool available for natural selection increases the vulnerability of agricultural crops to sudden and abrupt changes in climate or the appearance of pests and diseases. Since the beginning of this century about 75% of the genetic diversity amongst agricultural crops has been lost. Ways must be found to control the changes taking place and to assure their reversibility.

Since 1983 FAO has developed the global system on plant genetic resources. The objectives of this Global System are to ensure the safe conservation and promote the availability and sustainable utilization of plant genetic resources for present and future generations, by providing a flexible framework for sharing the benefits and burdens. The System covers the conservation (*ex situ* and *in situ*) and utilization of plant genetic resources - genes, genotypes and genepools - at molecular, population, species and ecosystem level. One hundred and thirty countries are formally part of the System.

There are three basic institutional components of the Global System:

The Commission on Plant Genetic Resources: a unique intergovernmental global forum where countries which are donors or users of germplasm, funds and technology can discuss, on an equal footing, matters related to plant genetic resources.

The International Undertaking on Plant Genetic Resources: a non-binding agreement to assure that plant genetic resources, especially species of present or future economic and social importance, are explored, collected, conserved, evaluated, utilized and made available for plant breeding and other scientific purposes. Complementary, negotiated agreements that have been incorporated into the Undertaking recognize national sovereignty over PGR and Farmers' Rights as "arising from the past and future contributions of farmers to conserving, improving and make available plant genetic resources", and it is agreed that these Rights will be implemented through a sustainable and transparent international fund to finance a PGR Global Plan of Action.

The International Fund for Plant Genetic Resources: provides a channel for countries, intergovernmental and non-governmental organizations, private industry and individuals to support conservation and promote the use of plant genetic resources on a sustainable basis, at world level. It is expected to become a critical element in ensuring the equatability of the Global System and the implementation of Farmers' Rights.

FAO Activities on Forest Genetic Resources (FI/EGR/92/6).

Forestry Department, FAO, Rome, Italy.

Abstract

FAO's activities related to forest genetic resources are guided by the Panel of Experts on Forest Gene Resources, a Statutory Body of FAO established in 1968.

Modest Regular Programme funds are available to support actions in response to needs identified by the Panel. In addition, externally procured funds contribute importantly to FAO activities, particularly in technical assistance projects in the developing countries.

General activities include mainly coordination and information with an annual newsletter, Forest Genetic Resources Information, published in three languages.

Exploration, collection and evaluation in field trials of forest genetic resources have, over the past decade, covered some twenty species both in dry and humid tropics. All work is done in collaboration with national institutes.

Ex situ conservation, by establishing provenance conservation stands in a range of environments, has so far concerned Pinus, Eucalyptus, Acacia and Prosopis species.

The Forestry Department is responsible for action on in situ conservation of plant genetic resources within the framework of the FAO Commission on Plant Genetic Resources. Work to date has concentrated on publication of information, support to pilot activities in tropical countries, and participation to the proposal of a network for in situ conservation of forest genetic resources in Europe. Conservation in situ, combined with both protected area management and the management of forests to provide a range of goods and services on a sustainable basis, is an important priority for future activities.

A large proportion of FAO field projects include assistance in establishing/strengthening national tree seed centres and related improvement/conservation programmes to build up national expertise and facilities which are required for wise and appropriate use of forest genetic resources.

Legal Aspects of the Conservation and Utilization of Aquatic Gene Resources (FI/EGR/92/7).

S. Boelaert. Private Consultant, Rome, Italy.

Abstract

Current action plans, past and ongoing negotiations on legal aspects of biodiversity tend to take too little account of the specificity of aquatic gene resources. A brief comparison between terrestrial and aquatic gene resources reveals that, apart from the lack of scientific knowledge on the genetics of aquatic ecosystems, the latter presumably differ quite sharply from terrestrial ones in their physical properties. Agricultural production further is mainly based on cultivated or cultured species, whereas approximately 85 percent of the prodcuction from fisheries comes from wild genetic resources. The legal regime of the law of the seas means in practical terms that Coastal States exercise more or less exclusive rights to fisheries resources in their exclusive economic zones (EEZ).

The aquatic genetic diversity is at present under threat from different, often overlapping causes: habitat destruction, several types of pollution, harvesting ways, patterns and technology of living and as well as other natural resources, aquaculture as such, accidental or deliberate release of exotic organisms, and global warming.

International and national laws have replied to a certain extent to each of these causes, tackling specific concerns at different jurisdictional levels and resulting, for instance in the case of pollution, control in a myriad of regulations. Only rarely, attempts to an integrated resource management have been made.

Early conservation efforts were driven by a concern for protecting the short-term economic potential of the fisheries resource and this same motive still seems to be paramount.

The response of the law to each of these threats has been partly been inspired by terrestrial methodology. On the one hand, one has the traditional in-situ conservation measures, aimed at establishing protected areas, of either single-use or multiple use, and accompanied by different management programs. A good example of an integrated approach to in-situ conservation including aquatic ecosystems is given by the recent EC directive of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora.

The present relevance of the ex-situ approach to aquatic gene resources on the other hand, is less obvious. Aqua- and mariculture could in certain cases, be of some value as living gene banks, but at present the poor control humans have on the aquatic life cycles and the difficulty of storage and manipulation of the aquatic gene pool, render their contribution problematic for many species.

Apart from fisheries regulations focussed on the preservation of the commercially important species, quite a few international conventions aim at protecting threatened or endangered aquatic species. The approach has its defects in that it is often centred on a few species only. These problem species are tackled when most of the harm has occurred, and often the convention fails to address the entire ecosystem. The United Nations Convention on the Law of the Sea (UNCLOS) convention is virtually silent on the matter of endangered species, and has specific clauses only on a few migratory species.

The bulk of the laws on the preservation of aquatic gene resources consists of fisheries regulations, naturally focussed on the theoretical goal of attaining the maximum sustainable yield of economically viable resources. These fisheries management programs and laws encompass elements such as fishing quotas and moratoriums, reorganization of the fishing fleet and the regulation of fishing technology. Under the UNCLOS convention, this fisheries regulation encumbs almost exclusively on the coastal states. With respect to the High Seas, UNCLOS stipulates in general that all states have the duty to cooperate in the conservation and management of the living

resources of the High Seas. Affected coastal states and states engaged in harvesting highly migratory species incur particular duties under UNCLOS.

The aquaculture branch, for its part, lacks similar legislation and management programs.

Pollution from several sources is addressed by an impressive number of treaties which do not always focus on aquatic life in particular, but have an indirect beneficial effect on reducing the stress on the aquatic environment. The paper will try to give an idea of the range of anti-pollution agreements that are relevant in this area. Anti-pollution measures offer as of now an incomplete answer to the stress on the aquatic environment, not in the least because problems such as pollution from land-based sources is hardly addressed. From a legal perspective, the often devastating effects caused by mostly accidental releases of exotic species in aquatic environments, could perhaps also be approached as a form of pollution.

Widening the scope of the last issue, the biotechnological products and their impact on the genetic diversity will be screened from a legal perspective. The legislation in this area is scarce, addresses mostly sanitary aspects and it is not clear for instance whether the two recent EC directives on the confined use and deliberate release of genetically modified organisms can be applied to aquatic organisms.

The final chapter of the paper deals with the issue of intellectual property rights and aquatic gene resources, and review other economic incentives and solutions offered by the field of ecological economics.

Genetic Markers and Mixed Stock Fisheries (FI/EGR/92/8).

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Abstract

Increasing uses of genetic markers in analyzing the composition of stock mixtures of salmonids have occurred since about 1980. Such analyses require the existence of genetic differences identified in baseline data from contributing populations, and an adequate sampling of the mixture. Applications have included estimates of geographic origins of groups captured in marine and freshwater fisheries, and of ancestral origins in populations reestablished from multiple sources. Although marine species are typically less structured than salmonids, the potential exists for analysis of stock mixtures in areas of intermingling of genetically distinguishable populations. A genetic substructure may be imposed on any population capable of artificial propagation through genetic marking by preferential breeding of genetically distinguishable individuals.

Effects of Fishing on Genetic Resources of Aquatic Organisms (FI/EGR/92/9).

Y.P. Altukhov. Russian Academy of Sciences, Moscow, Russia.

Abstract

This paper is the generalization of various data both from the author's works and worldwide literature concerning the effects of fishing on the genetic structure of populations. Key points provide evidence that:

1. The fishing of ecologically different species usually leads to biological changes, such as, decrease in body size, increase in growth and maturity rates, unfavourable changes in a population sex ratio, and decrease of mean generation length.

2. As was clearly demonstrated for Pacific salmon, the reason for such reactions is the selective character of fishing, which distorts the systemic organization of populations and, correspondingly, their optimal genetic structure.

3. The fundamental sense of such an optimal structure can be defined as follows: both increase and decrease in genic diversity of populations compared with evolutionary formed level are unfavourable for normal system functioning.

4. Russian data from selected loci of sockeye salmon indicated that selective fishing removes larger, older, more homozygous fishes, leaving more heterozygous smaller fishes nearly intact. This leads to the increase in genic diversity (heterotic effects), and, consequently, to the acceleration of growth and sexual maturity rates, to the decrease of fish size, to the fall of total fecundity and thus to the decline in number and biomass. Somewhat contradictory trends were observed in the fishery for orange roughy in the South Pacific. This fishery, which concentrated on spawning grounds, removed older more heterozygous fish, thus decreasing intra population genetic diversity.

5. The selectivity vector in artificial reproduction on the hatcheries can also be important when larger fishes (mostly males) are used for breeding. This may lead to the loss of genic diversity, to the dramatic distortion of the optimal sex ratio, to the decline in number, and to the irreversible degradation of populations.

6. The only reasonable strategy of rational fishery management is to take the internal structure of the species into account, to distribute fishing and management efforts evenly and proportionally over all structural components, that is, genetically distinct populations.

The concluding part of the paper is a review of:

(a) our gaps of knowledge concerning genetic effects of fishing
(b) the proposals for perspective fields of international cooperation.

Protection of Rare Aquatic Wild Animals in China (FI/EGR/92/10).

Li Sifa. Shanghai Fisheries University, Shanghai, China.

Abstract

The "Protection Law of Wild Animals in the People's Republic of China" was issued on 8 November, 1988, and has been implemented since 1 March, 1989. On 10 October, 1988, the National Council published the "List of Wild Animals to be Protected Under the National Level".

There are two levels of protection for rare animals in China.

It is prohibited to hunt animals at the first level of protection unless a special hunting license is obtained from the Wild Protection Agency of the National Council.

It is prohibited to hunt animals at the second level of protection unless a special hunting license is obtained from the Wild Protection Agency of the Provincial Government.

Five case studies are presented on Lipotes vexillifer, Psephurus gladius, Myxocyprinus asiaticus, Acipenser sinensis, and Trachidermus fasciatus.

1. Lipotes vexillifer

The rarest freshwater whale in the world, it is found in the Chnagjiang River. It matures at 4 and 6 years old for males and females, respectively. After maturing, the female produces one offspring every two years. It preys on fish and the daily ration is 10-11%.

Since the 1960s its numbers have declined rapidly. The reasons for this decrease are: (1) mortality from harmful fishing tools; (2) habit alteration; (3) interference by navigation, such as the noise from boats; (4) pollution; (5) low fecundity. It is estimated that its current population size is only 200-300 individuals. Three protection areas have been set up in the Changjiang River.

2. Psephurus gladius

This species is found in the middle and lower branch of the Changjiang River. Maximum length may reach 7 m, it is carnivorous and matures at 5 years for males and 7 years for females. Since the 1980s, its numbers have been decreasing rapidly. Analysis of sampling data of June-August at the estuary of the Changjiang River revealed that 587, 9, 84, 2, 5, 0, and 0 specimens were collected from 1983 - 1990, respectively (no collection was made in 1987).

3. Myxocyprinus asiaticus

The only species of the *Catostomidae* family in China. Body weight can reach 40 kg. This species feeds on benthos and has an absolute fecundity of 211000-390000 eggs.

4. Acipenser sinensis

Acipenser sinensis is found in the Chanjiang River. It is a large-sized species with a normal body weight of 200-300 kg; the largest recorded specimen was over 500 kg. To save this species, a hatchery has been established under the Guozhouba dam of the Changjiang River. Artificial induced reproduction has been successful, and the hatched fry and fingerlings have started to be released into the river.

5. Trachidermus fasciatus

This is a very famous species within China. Since 1987, its population has decreased. The reasons are: habit alteration, water conservancy construction, pollution and overfishing. Its biology and ecology are still not yet well understood and its artificial reproduction has not been a success.

Genetic Conservation of Freshwater Fishes in China (FI/EGR/92/11).

Li Sifa. Shanghai Fisheries University, Shanghai, China.

Abstract

There are over 800 species of freshwater fishes in China. 90% of these fishes are distributed naturally in China and/or in east Asia only.

With the overall rapid development of the country and owing to the ever-increasing demand for fish as food, the aquatic ecosystems are under constant pressure from man-induced stresses. The fish habitat is being destroyed by the alteration of river systems, increased land development, overfishing of important fishes, pollution, and domestication and introduction of species.

It is estimated that there are 98 endangered species (9 orders, 24 families and 80 genus) in China. Causative factors include introductions of exotic fishes, destruction of the fish habitat, and overfishing.

Since the 1980s the study on genetic resources and their conservation has been ongoing in China. Major achievements include genetic and performance evaluation of chinese carps, evaluation of environmental factors on gonad development and age of maturity in Chinese carps, genetic and morphological evaluation of blunt snout bream, and establishment of live fish gene banks which include ponds, tanks, aquaria, as well as the establishment of a cryogenic gene bank. Current national research programmes and a framework for genetic conservation are also presented.

Methods for Assessing Genetic and Biological Diversities (FI/EGR/92/12).

D. Hedgecock. Bodega Marine Laboratory, Bodega Bay, CA, 94923, USA.

Abstract

Morphological and molecular methods that have been used to assess genetic variation among individuals, populations, or taxa of aquatic organisms are reviewed. Two scales are used to compare the utilities and resources. The first scale describes where in the hierarchy of biological organization the management problem lies; this axis is not independent of temperate to tropical gradients in both biodiversity and economic development. The second axis describes relative cost in terms both of equipment and materials and technical sophistication required to understand and apply the method.

Methods for measuring variation in morphology (morphometrics, meristics) are traditional, inexpensive but powerful, especially when combined with multivariate statistical methods. The genetic basis of morphological variation is generally not ascertainable in studies of natural populations; indeed, at close taxonomic levels one may draw misleading conclusions about genetic relatedness from morphological data. However, morphology generally discriminates effectively at higher taxonomic levels and thus tends to be a reliable indicator more of biodiversity than genetic diversity. Moreover, morphological means for distinguishing closely related, cryptic forms are often found after molecular diagnosis is possible.

The first analyses of biochemical variation among organisms were based on studies of proteins, first through immunological methods and then through electrophoretic separations. Isozyme or allozyme analysis has been particularly useful in recognizing taxa, populations and even individuals and its many successful applications to fisheries management and aquaculture are well known. Allozyme methods require some background in basic laboratory chemistry and biochemistry but they are relatively inexpensive and routinely applied throughout the world. In some cases, there may be insufficient variation in proteins to study certain population-level problems, or the amount of biochemical activity of the biological samples available preclude allozyme study. If so, then one steps up in technical sophistication and expense to a variety of methods based on analysis of polymorphism in deoxyribonucleic acids (DNA).

Digestion of DNA with bacterially derived restricton enzymes that recognize and cleave the double helix at specific sites is the most common method for revealing variations called restriction fragment length polymorphisms, or RFLPs. RFLP analyses, particularly of mitochondrial DNA, have been used to discriminate at the population level and above; they require technical sophistication and are sufficiently laborious to limit sample sizes to a few hundred in the largest of studies. RFLP analysis of nuclear DNA, combined with hybridization to probes of repeated DNA sequences (micro- or minisatellite DNA), reveal an extraordinary amount of genetic diversity and potentially allow discrimination of individuals; these methods will be invaluable in breeding and conservation programs.

The advent of a method for enzymatic amplification of specific DNA sequences by the polymerase chain reaction, or PCR, has opened up numerous opportunities for measuring genetic diversity. Because a single template molecule can in principle be exponentially multiplied in a matter of hours, genetic information can be obtained from small, fixed, or even degraded biological samples. A variety of methods for rapidly characterizing amplified DNA have been developed. Though initial research is very expensive and technically demanding, PCR-based methods should in the long run facilitate large-scale population studies and be reduced to routine practice by medium-skilled laboratory personnel.

In summary, in going from morphology to molecules, cost and technical sophistication of methods increase while focus shifts from measuring biodiversity to genetic diversity and ultimately to the population processes that underly the origin and maintenance of genetic variation. In managing the

utilization and conservation of genetic resources problems must be matched to the most appropriate, cost-effective technology.

Ecological and Regulatory Uncertainties Associated with Transgenic Fish (FI/EGR/92/13).

E.M. Hallerman[1] and A.R. Kapuscinski[2]. [1]Virginia Polytechnic and State University, Blacksburg, VA 24061-0321, USA. [2]University of Minnesota, St Paul, MN, 55108, USA.

Abstract

The development of transgenic fishes introduces ecological and public policy uncertainties which may constrain the rate of progress towards practical utilization. Pathways giving rise to ecological impacts of transgenic fishes in natural communities may prove complex, and the magnitude of such impacts difficult to predict. Continuing uncertainty over policies regulating environmental release and commercial use has slowed the pace of development of genetically modified organisms. Knowledge of the benefits and risks of using transgenic fishes, effective exercise of regulatory authority and public confidence in each of these will prove important in determining whether transgenic fishes reach practical utilization.

Field Experience with Cryopreservation, a Practical Tool for Genetic Conservation in fishes (FR/EGR/92/14).

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Abstract

Fish populations that are managed for food production or for rebuilding wild stocks tend to suffer sooner or later from inbreeding and genetic drift. Genetic drift results when a hatchery's original selection of broodstock doesn't represent the overall genetic variability available in the wild (a "bottleneck"). When these broodstock are overworked as breeders (which is easy to do if they are very fecund), the resulting inbreeding erodes fitness even more.

The effects of this "broodstock squeeze" on fish farming and ocean ranching operations are gradual but devastating, and they're particularly hard to assess in stock-rebuilding programs that release huge numbers of hatchery-produced fry into the wild. The classic broodstock management strategy for eliminating inbreeding and genetic drift is well known and involves increasing the effective breeding number (N_e) either by acquiring new broodstock that have not already passed through a bottleneck, or by changing the sex ratio of breeders.

Cryopreservation of fish sperm makes it relatively easy to inject new genetic material without necessarily collecting new broodstock from the wild or transporting broodstock from another culture site. If wild stocks are endangered or physically or bureaucratically hard to collect, cryopreservation may be the *only* practical way to increase N_e. In this paper we describe recent practical experience freezing sperm from a number of important cultured fish, with emphasis on a classic developing food-fish industry (culture of *Colossoma* in Colombia and Brazil) and on the loss of fitness in salmon hatchery production. In both cases, field tests of new, simple cryopreservation techniques clearly demonstrate the potential and local acceptance of the technology.

Biodiversity and Aquaculture in Southern Africa (FR/EGR/92/15).

B. Haight. ALCOM, Harare, Zimbabwe.

Abstract

FAO through ALCOM, the Aquaculture for Local Community Development Programme, is advising fisheries administrations in Southern Africa, comprising the ten nations of the Southern African Development Community, on guidelines for transfers and introductions of aquatic species for aquaculture, habitat conservation especially for natural populations of tilapias, and breeding programmes for tilapia culture. Actions to maintain important elements of aquatic biodiversity in this region must be balanced against the need for rapid economic development.

The Southern African region includes most of the rift valley lakes with their large and ecologicaly important assemblages of cichlids. Bimodal rainfall patterns, with annual average precipitation decreasing to the south, and a high interior plateau, do not favour year around tilapia culture. Pond restocking is often needed after drought periods.

Fish resources currently used for aquaculture include nine species of indigenous and introduced tilapias, one species of catfish, and introduced cyprinids, salmonids and centrarchids. There has been widespread and uncontrolled breeding of different genetic strains of tilapias in southern Africa. There is no agreed regional code of practice on introductions and transfers of aquatic organisms, and national codes are outdated or poorly enforced.

Southern African economies are characterized by rural farming with low production based on rainfed cereal and tuber crops, grazing livestock, and fishing, relatively low population density in the rural areas, and high rates of urbanization in some cases.

Fish culture falls roughly into two classes. Most fish farmers practice extensive culture of local tilapias in earthern ponds under near-natural but highly variable conditions. An emerging class of entrepreneurial farmer is taking up semi-intensive fish farming under more predictable conditions. There is also widespread fishing in thousands of permanent and seasonal small water bodies built for domestic and cattle use. Most of these water bodies are colonized by riverine species, although the practice of culture-based fisheries is expanding.

Under these conditions, several issues need close attention in conservation and breeding programmes. Guidelines for transfers and introductions must be enforceable and recognize that the political boundaries do not following the river and lake basins. A regulated and consistent means of producing and supplying fingerling to farmers must be developed, at first for wild stocks of local tilapias which perform well under the highly varied and unpredictable conditions of extensive fish farming. Such a system will help to minimize the spread of unknown strains and establish the framework for future distribution of breeds for semi-intensive and intensive fish farming.

Promoting On-Farm Genetic Conservation in Aquaculture (FR/EGR/92/16).

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Abstract

Genetic improvement of aquaculture strains and conservation of genetic diversity should have equally high priority in any enlightened agenda for development. Unfortunately, these two goals of natural resource development often interfere or compete with each other. A loss of genetic diversity has occurred in all commodity and food plants during the genetic revolutions of this century and is still taking place despite strong efforts by CGIARs and other organizations to prevent it. A comparable genetic revolution in aquaculture is about to begin, and we now understand that the goal of genetic improvement must be reconciled with the goal of genetic conservation.

The seminar will first outline the reasons for believing that the problem of aquaculture genetic conservation has a strong socio-economic component. Genetic gain is supported by the short-term economic motivation of farmers, who in general wish to increase yield and profitability. The support for genetic conservation is essentially external (to the farming community), and takes a long-term view of economic profitability.

Optimizing the trade-off between genetic gain and loss of diversity will require a comprehensive study of the various technology options available for aquaculture broodstock conservation and improvement. There are several types of genetic selection procedure, operating on different geographical scales, that have different consequences both for genetic gain and biodiversity loss. Some types of selection programme may be simple and cheap enough to be locally profitable in the short term and may therefore promote the conservation of local broodstock diversity.

The state-of-the-art of DNA fingerprinting is briefly reviewed, and it is suggested that this procedure may allow us to monitor the rates of gene flow among breeds and the rate of genetic erosion of breeds. It may also allow us to develop new procedures for local broodstock improvement and conservation, because it greatly facilitates pedigreeing of lines, on-farm progeny testing and other procedures that are commonplace in animal breeding.

The Project on Genetic Improvement of Farmed Tilapias (GIFT) (FR/EGR/92/17).

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Abstract

Combined improved knowledge in nutrition, farming systems, health care, and animal breeding and genetics has led to significant increase in the productivity of crop plants and domestic animals. It is difficult to assess quantatively the contribution of each discipline, however, at least 30% of total gains in the rate and efficiency of production can be attributed to genetic improvement. Genetic improvements are cumulative and permanent. The estimated benefits to cost ratios of genetic improvement programs range from 5 :1 to 50 :1. this ratio is likely to be much higher in the developing world, both in financial terms and more significantly for service to very human needs.

While significant contributions have been made in areas of fish health, fish farm management, and nutrition, aquaculture has so far remained almost untouched by scientifically based husbandry and genetics. Consequently, aquaculture stocks used throughout Asia, the area that produces most of the world's farmed aquatic produce, are generally similar to wild undomesticated fish. In the Philippines and elsewhere there is evidence of genetic deterioration. There are several reasons for this.

According to the conventional wisdom in the aquaculture science establishment, classical animal breeding principles did not apply to fish. Some so-called "domesticated" fish populations were believed to have reached selection plateau, the heritability of economic traits was not well known or considered close to zero, and selection would not work. Some even argued that conventional animal breeding programs would lead to a loos of genetic diversity. Others maintained that any possible gains from genetic research would require very long-term investment. As a consequence, the science of applied fish breeding is several decades behind animal and plant breeding. The cost of lost opportunities are incalculable.

The genesis of GIFT

ICLARM started in the mid-1980s to explore a research program to develop improved breeds of fish grown in inland aquaculture systems by small-scale farmers. Tilapias were chosen as prominent test species because of their growing importance in warm water aquaculture in Asia and Africa, and their utility in investigating the application of genetics in aquaculture, from conservation of genetic resources to breeding programs. the GIFT project was established in 1988 through collaboration among the National Freshwater Fisheries Technology Research Center of the Philippine Bureau of Fisheries and Aquatic Resources (NFFTRC/BFAR), the Freshwater Aquaculture Center of the Central Luzon State University (FAC/CLSU), the Marine Science Institute of the University of the Philippines (UPMSI), AKVAFORSK of Norway and ICLARM. The expertise required to implement the project was thus secured by bringing together institutions with experience in: tilapia farming (BFAR, FAC); genetic status of wild and culture tilapia stocks (UPMSI, ICLARM); and application of genetic improvement strategies (AKVAFORSK, ICLARM). Support came from the Asian Development Bank and the United Nations Development Programme/Division for Global and interregional Programmes (UNDP/DGIP). The project plans were circulated for peer-review to 25 international experts before implementation.

The project's primary objective is to develop effective approaches and methods for the production of improved breeds of Nile tilapia for low-cost sustainable aquaculture.

The process - From Systematic Documentation to Improved Breeds

Because of the pioneering role of the GIFT project, an elaborate design was chosen to seek answers to a broad range of basic problems in fish breeding programs. The project's team had to

invent and adapt methods for controlled mating, tagging, sampling, recording traits, managing databases, and rigorous statistical analyses. Despite setbacks from a series of natural calamities in the Philippines, the GIFT team followed an exacting sequential approach from systematic documentation of the poor status of Asian cultured stocks, collection and transportation of new germplasm from Africa to Asia with thorough quarantine; rigorous evaluation of promising strains; establishment of a base population; and plans to develop improved breeds of tilapia for a wide range of farming systems and agroclimatic conditions. The series of experiments conducted are considered significant landmarks in aquaculture research by senior peers worldwide.

The background work for the project was initiated during a special Workshop on tilapia Genetic Resources for Aquaculture in 1987 which concluded that the established farm stocks in Asia do not form the best genetic base for a genetic improvement program because of their small founder populations, possible inbreeding and introgression of genes from other tilapias. These problems were documented and decisions were taken to collect new germplasm from Africa: Egypt, Ghana, Kenya and Senegal. The strategy was to evaluated new germplasm along with four established farmed stocks in the Philippines in diverse tilapia farming systems.

For each country, 150 - 160 breeders or 200 - 800 fingerlings were shipped. On arrival the fish were held for three to seven months in quarantine.

The project's first generation experiment focused on estimating the magnitude of genotype X environment (GE) interaction. 11,400 tagged fingerlings were communally reared for 90 days in 11 different test environment, representing a wide range of tilapia farming systems. The GE interaction was low, indicating no need to develop specialized strains for each of the different farming systems used in the test. Some of the African wild strains grew faster than the farmed strains. This was followed by a complete 8 x 8 diallele crossing experiment, producing all 64 possible hybrid crosses among the strains in order to estimate the magnitude of heterosis or 'hybrid vigor' and thereby the breeding strategy; selection or crossbreeding. The gain in growth and survival by crossbreeding was too low to be of significance in an applied breeding programme.

A simple selection strategy was then started by selecting best growing breeders from the 25 best performing purebred and crossbred groups (out of the 64 evaluated) to build a genetically mixed base population. The synthetic breed served as the base for further generations of selection. The individuals most likely to produce the best offspring were then chosen as breeders in each successive generation. A combined family and within family selection strategy was adopted. The potential breeders were ranked based on 'breeding value', i.e., the additive genetic value of an individual, judged by performance of the individual itself and its full- and half- sibs. From the third generation onwards, about 20,000 tagged fingerlings from 120 - 200 full-sib families (within 50-100 half-sib families) have been communally tested in each generation in a variety of test environments.

After one generation of selection in the synthetic breed, the selected fish grew 23 % faster than the previous generation and 75 % faster that the most common commercial strain in on-station trials. In on-farm trails, the GIFT fish grew on the average 60 % faster than present farm breeds. Their survival was almost 50% better. A survey in three provinces in the Philippines, indicated that presently farmed breeds reach a harvest size of about 80 g after a growing period of five to six months, permitting about two crops per year. The GIFT fish reach the same harvest size in three months, permitting three crops per year. This can translate into increases in annual production and gross revenue. Furthermore, the improved fish to be disseminated to farmers will include, through selection, a cumulative increase in growth rate of about 10% per generation.

Cognizant of the positive and negative lessons learned from plant and livestock breeding the GIFT team developed strategies for an "Integrated Breeding and Dissemination Plan" that takes into account conservation of biodiversity and indigenous knowledge on genetic resources.

National Breeding programs

So far there are almost no sustained applied fish breeding programs in developing tropical countries. The GIFT project is therefore a pioneering effort. It has stimulated the Philippines to develop a self-sustaining national breeding program. The "super" tilapia breed developed through the GIFT Project was formally turned over to the Philippines farmers in May 1993 by the President of the Philippines, Fidel V. Ramos.

Dissemination of genetic gains will be done through national broodstock centers (breeding nucleus) and nationwide satellite stations (multipliers), with extensive participation of farmers. The project pictures a farmer-run tilapia breeding program in the Philippines after a few years and the initiation of similar efforts in other countries.

The success of the GIFT project has brought increased donors' confidence in funding aquaculture genetics research. Several donor agencies, namely NORAD, ACIAR, DANIDA, JICA, have either initiated or are in the process of initiating applied fish breeding research in different countries in Asia and Africa.

Effects of Selection for Polygenic Traits on Genetic Diversity (FR/EGR/92/17A).

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Abstract

The impacts of genetic interactions between fish populations on genetic diversity and local adaptation have been subject to increased awareness during the last years. This is coinciding with the international concerns on biological diversity expressed eg. by the recent UN Conference on Environment and Development. Genetic interactions may occur as a result of fisheries enhancement programs based on hatchery stocks or transplanted stocks. The rapid growth of the aquaculture industry and the efforts to produce high yielding, domesticated breeds or strains for culture are also matters of concern, because of possible interactions between farmed and wild stocks.

However, the concept of genetic diversity seems to be poorly defined. The term is frequently used without discriminating between diversity at the species level and diversity at the population level within a species. Species are obviously unique evolutionary products. On the other hand, selective diversification between populations within species may occur without divergent fixation of genotypes or alleles. Such populations may not be regarded as irreplaceable genetic entities. Adaption to specific environments may then be generated (or regenerated) by natural selection.

A simplified polygenic model is presented, and it is shown that considerable response to selection may be obtained for polygenic traits without essential changes in allele frequencies and genetic variability, and that the probability of fixation of alleles or genotypes because of selection will be low when the trait is affected by a large number of loci. The span between the extreme fixed genotypes for such traits may easily become wider than what may be realized under normal biological conditions.

Standardization of Infra-Specific Nomenclature in Aquaculture (FR/EGR/92/18).

D.M. Bartley. Fisheries Department, FAO, Rome, Italy.

Abstract

The optimum utilization and conservation of aquatic resources in aquaculture is hampered by a lack of standardized information on the available resources. As early as 1966 the FAO World Symposium on Warm Water Pond Fish Culture Program recognized the need for an international system to designate strains and stocks of fishes. Although this need has been stressed in international symposia numerous times since, there is no internationally accepted definition of breed, strain, or variety of farmed aquatic organisms. The improvement of infra-specific nomenclature in aquaculture will be necessary in light of the increased importance of genetic resources in aquaculture production, especially in the areas of genetically improved and genetically modified organisms. Additionally, an improved nomenclature will be essential in efforts to catalogue and document the intra-specific variability in commercially important species through databases such as the Registry of North American Trouts maintained by the US Fish and Wildlife Service and Fishbase from the International Center for Living Aquatic Resources Management.

Surveys of definitions and practices from livestock and rice breeding literature, as well as a survey of definitions used in the aquatic sector, were conducted in order to arrive at a proposal for a useful system of nomenclature and protocol for strain designation in aquaculture. The following proposals are presented:

1) accept as a standard definition of "strain" the wording of Kincaid (1987), "a population that has reproducible physiological, morphological, or cultural performance characteristics that are significantly different from those of other fish populations of the same species, or a brood stock derived from such a population and maintained thereafter as a pure breeding population" with the addenda that a) "strain" only be applied to fish that spend some or all of their life in a culture environment (thus, there would be no wild strains of fish except in culture), b) strains are differentiated on criteria other than main morphology which will be used to designate breeds, c) a certain of amount of introgression (see 3 below) is permissable, d) performance of strain must be evaluated in different environments for several generations in order to confirm its distinction and e) under certain conditions a group of fish may be designated a strain in the absence of obvious distinguishing characters;

2) determine the length of time a group of fish could be in a new culture environment and under certain selection intensity before significant genetic changes occur;

3) preserve the genetic differentiation among strains (F_{ST}) by allowing a level of gene flow (Nm) not to exceed the level determined from the relationships of Ryman (1991).

4) require a strain have an effective population size of at least 50;

5) common names of strains may be based on any of the criteria of Mason (1988), but with full regard to items 1-4 above;

6) designate a short hand code for a strain registry that would be used in conjunction with the name (5 above), and would contain information on species, subspecies, origin, hybridization (genetically modified organisms and hybridizations above the species level would require special treatment);

7) continue and expand strain registries of commercially important aquatic species;

8) recommend data on strains be kept for all FAO aquaculture projects in a standard format;

9) maintain summary indices of genetic diversity and a phenogram based on genetic distances for all strains within a species;

Kincaid, H. 1987. In K. Tiews (editor), Proc. World Symposium on Selection, Hybridization and Genetic Engineering in Aquaculture, Vol II.
Mason, I.L. 1988. Evolution of Domesticated Animals
Ryman, N. 1991. J. Fish Biol, 39(A): 211-24.

Fisheries Research in FAO (FR/EGR/92/19).

Fisheries Department, FAO, Rome, Italy.

Abstract

FAO has a clear mandate to undertake, promote and support management and development-oriented fishery research at the international level (at Headquarters), the regional level (in support to regional FAO and non-FAO fishery bodies) and at the national level (through the activities of the FAO Field Programme). FAO is not an aid agency or agricultural bank, but a unique source of independent expertise and information for research and development that provides member countries with a forum where they can identify and resolve shared problems, share research competence and data, and agree on cooperative or coordinated action.

FAO has at its disposal a variety of means and mechanisms to support it tasks in fishery research: a competent scientific core staff; an extensive fisheries library; systems of information including computerized databases related to fishery statistics, projects, and bio-economic data; regional fishery bodies; and an important field programme. In addition, the Fisheries Department is well positioned to draw from the rest of the organization research competence in the fields of land and water management, agriculture, animal and crop production, forestry management, and human resources.

The needs of FAO's Member Countries are reflected in the Fisheries Department's programme. This programme is the result of substantial participation by the Members and should therefore, reflect their most pressing needs. The Fishery Department's research activities cover a broad spectrum: marine resources, inland fisheries and aquaculture, fishing technology, post-harvest technology, economics, marketing, policy and socio-economics. These activities should only be considered as indicative of national needs. Attempts to determine specific research priorities for a given area must involve the countries concerned. In this process, FAO's assistance would be in interpretation of data, policy guidance, technical support, regional coordination and dissemination of information.

Implications of UNCED on the Fisheries Department Work Programme (FR/EGR/92/20).

Fisheries Department, FAO, Rome, Italy.

Abstract

The United Nations Conference on the Environment and Development (UNCED) convened in Rio de Janeiro, June 1992. The results of UNCED most relevant to the Fisheries Department are the Convention on Biodiversity and a 700 page programme of action called "Agenda 21". FAO played a significant role in the negotiating process of UNCED and now these outputs will figure heavily in the Fishery Department's programmes as FAO prepares for follow up activities. To a large extent the responsibilities for follow-up action will fall on Member Countries. However, it is clear that considering the uncertain and limited funding, countries will require financial and technical assistance from international and other organizations.

The primary aim of UNCED is to promote a better integration between environmental and developmental objectives throughout the world. To reach this aim it will be necessary to establish new and equitable partnerships at all levels of society. The results of UNCED are envisioned to be the reduction of poverty, the equitable sharing of resources and benefits from them, and an environment that can be enjoyed by future generations.

Agenda 21 contains many sections of relevance to the Fisheries Department. The most relevant are Chapter 15: Conservation of Biological Diversity; Chapter 17: Protection of the Oceans, all kinds of seas, including closed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their living resources; and Chapter 18: Protection of the quality and supply of freshwater resources: application of integrated approaches to the development, management and use of water resources.

The sustainable use or development of resources is a primary mechanism in achieving the goals of UNCED. Towards that end, the Fisheries Department plans or has in place activities on fisheries management and stock identification, by-catch, high seas management, coastal integrated management and environmental degradation, increased peoples participation in resource management, management in an uncertain context (precautionary principle), and the establishment of property or user rights for aquatic resources. Activities are also underway on the conservation of aquatic resources in aquaculture and inland waters.

Annex F

LIST OF DOCUMENTS

Document No.	Title
FI/EGR/92/1	Prospectus
FI/EGR/92/2	Agenda
FI/EGR/92/3	The Role and Progress of FAO in the Utilization and Conservation of Genetic Resources of Aquatic Organisms
FI/EGR/92/4	Animal Genetic Resources
FI/EGR/92/5	FAO Global System for the Conservation and Sustainable Use of Plant Genetic Resources
FI/EGR/92/6	FAO Activities on Forest Genetic Resources
FI/EGR/92/7	Legal Aspects of the Conservation and Utilization of Aquatic Gene Resources
FI/EGR/92/8	Genetic Markers and Mixed Stock Fisheries
FI/EGR/92/9	Effects of Fishing on Genetic Resources of Aquatic Organisms
FI/EGR/92/10	Protection of Rare Aquatic Wild Animals in China
FI/EGR/92/11	Genetic Conservation of Freshwater Fishes in China
FI/EGR/92/12	Methods for Assessing Genetic and Biological Diversities
FI/EGR/92/13	Ecological and Regulatory Uncertainties Associated with Transgenic Fish
FI/EGR/92/14	Field Experience with Cryopreservation, a Practical Tool for Genetic Conservation in Fishes
FI/EGR/92/15	Biological Diversity and Aquaculture in Southern Africa
FI/EGR/92/16	Promoting On-farm Genetic Diversity in Aquaculture
FI/EGR/92/17	The Project on Genetic Improvement of Farmed Tilapia (GIFT)
FI/EGR/92/17A	Effects of Selection for Polygenic Traits on Genetic Diverstiy
FI/EGR/92/18	Standardization of Infra-specific Nomenclature in Aquaculture
FI/EGR/92/19	Fisheries Research in FAO
FI/EGR/92/20	Implications of UNCED on the FAO Fisheries Department Work Programme
FI/EGR/92/21	Agenda 21, Chapter 14
FI/EGR/92/22	Agenda 21, Chapter 15
FI/EGR/92/23	Agenda 21, Chapter 16
FI/EGR/92/24	Agenda 21, Chapter 17
FI/EGR/92/25	Convention on Biological Diversity
FI/EGR/92/26	List of Participants
FI/EGR/92/27	List of Documents

Annex G

AGENDA

Sunday, 8 November

17.00 Leave FAO Headquarters, Viale delle Terme di Caracalla, for Villaferrata in Grottaferrata

Monday, 9 November

09.00 1. Welcome, FAO and University of Rome representatives

09.30 2. Adoption of agenda, introductions, appointment of Chairmen, and designation of Rapporteurs

09.45 3. FAO mandate and role in international fisheries and aquaculture development, objectives of the Consultation, and progress since 1980

10.30 Coffee Break and DSA disbursement

11.00 4. FAO experience papers in genetic resources of:
- 4.1 animals
- 4.2 forests
- 4.3 plants
- 4.4 policy and regulatory aspects of fishery genetic resources

13.00 Lunch

14.30 5. Contributed background papers
- 5.1 Genetic stock identification in fisheries, Utter/Ryman
- 5.2 Effects of fisheries on genetic resources, Altukhov
- 5.3 Aquaculture and genetics in China, Li Sifa

16.00 Coffee

16.30 6. Chairmen and Rapporteurs meeting

20.00 Dinner at Villaferrata

Tuesday, 10 November

09.00 7. Contributed background papers (continued)
- 7.1 Methods of genetic analyses, Hedgecock
- 7.2 Concerns for biotechnology in aquaculture and fisheries, Hallerman/Kapuscinski
- 7.3 Cryopreservation in genetic conservation, Harvey
- 7.4 Biodiversity and aquaculture in southern Africa, Haight

11.00 Coffee

11.30 8. Contributed background papers (continued)
- 8.1 Promoting genetic diversity in aquaculture, Doyle
- 8.2 Genetic improvement in farmed fishes, Eknath
- 8.3 Effects of selection for polygenic traits on genetic diversity, Bentsen
- 8.4 Standardization of "strain" nomenclature, Bartley

13.00 Lunch

14.30 9. Divide into working groups: Aquaculture, Fisheries, Natural Populations, and Policy and Regulatory Aspects

16.00 Coffee

16.30 Working groups (continued)

20.00 Dinner in Frascati

Wednesday, 11 November

09.00 10. Reports and discussion of Working Groups in plenary

10.30 Coffee

11.00 10. Reports in plenary (continued)

13.00 11. Departure to the University of Rome, Tor Vergata
Lunch and afternoon in Tor Vergata

20.00 Dinner, Villaferrata.

Thursday, 12 November

09.00 12. Reform working groups

11.00 Coffee

11.30 13. Begin drafting of recommendations from Working Groups

13.00 Lunch

14.30 14. Plenary meeting on International Networks, Epifanio
Group discussion and recommendations

16.00 Coffee

16.30 International networks (continued) or work as needed on documents

Friday, 13 November

09.00 15. Discussions of recommendations of Working Groups in plenary

11.00 Coffee

11.30 16. Working Groups, editing of documents

13.00 Lunch

14.30 17. Summary of documents from Working Groups by the Working Group Chairmen
18. Concluding remarks on consultation by the Chairman

16.00 Coffee

17.00 Check out and depart for 20.00 dinner in Rome

Annex H

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This report discusses the need and methodologies for the utilization and conservation of genetic resources of aquatic animals. More than a review of genetic principles and technologies, the report addresses the application of such principles and technologies in development and conservation projects and research. Specific recommendations are made with regard to the genetic resources in natural populations, fisheries stocks and aquaculture. Recommendations concerning regulatory, policy and legal aspects of aquatic genetic resources are also presented. The report also contains abstracts of the contributions presented to the consultation.

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